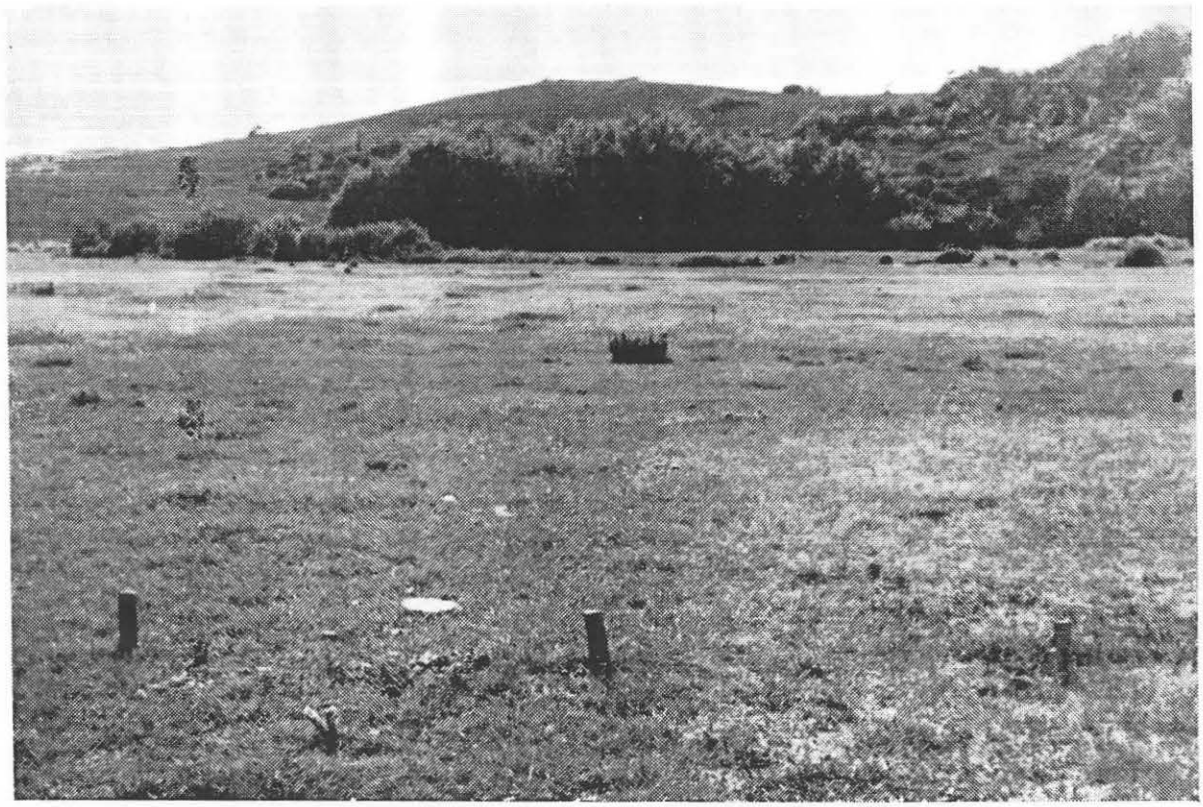

T. WEIS-FOGH:

ECOLOGICAL INVESTIGATIONS ON MITES AND COLLEMBOLES IN THE SOIL

APPENDIX:
DESCRIPTION AF SOME NEW MITES (ACARI)

NATURHISTORISK MUSEUM, AARHUS
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PREFACE

For the years 1942-44 the University of Copenhagen invited competitors to write a zoological prize essay on the ecological and phenological conditions of some arbitrarily chosen microfauna, and the present investigation, which is concerned with the microscopic arthropod fauna of the soil, owes its origin to this prize competition. The lines on which such a work must be carried out are at present only partly laid down, hence it cannot surprise that a publication of this kind must be of a somewhat provisional character.

The work was done on the reservation with appertaining laboratory, »The Mols Laboratory«, at the disposal of the Natural History Museum and situated on Mols, part of the southern tract of the peninsula Djursland in Jutland (cf. THAMDRUP 1947 b), and it is due to the ideal working conditions which this laboratory offers its guests that I was able to carry through the investigation. While I have thus to acknowledge my indebtedness to the persons and institutions that support the laboratory, I have no less pleasure in thanking the leader of the laboratory Mr. H. M. THAMDRUP Ph. D. Director of the Natural History Museum at Aarhus, on whose initiative I took up the work, and who has helped and supported me in every way. The realisation of Dr. THAMDRUP's idea of establishing a closer co-operation between the various branches of ecological science, e. g. between zoology and botany, as now practised at the Mols Laboratory, has been a very valuable help to me, and I should like here to thank all collaborators at the laboratory, especially Mr. C. OVERGAARD M. Sc. and Mr. M. KØIE M. Sc., who amongst other things let me have some of his analytical results.

Part of the material was worked up at the Natural History Museum at Aarhus, but the main part was treated at the Institute for Comparative Anatomy at Copenhagen, to whose leader, the late Professor C. M. STEENBERG († 1946), together with Dr. P. HOLST CHRISTENSEN I owe thanks for aid of various kinds, particularly for the good working conditions constantly at my disposal. Some of the systematic investigations were, however, made at the Zoological Museum at Copenhagen, to whose Keeper Professor R. SPÄRCK, I am indebted for working facilities, the loan of preparations, and other help, while I thank Dr. S. L. TUXEN for the material put at my disposal. I futher wish to thank

Professor I. TRÄGÅRDH Ph. D. and H. M. FORSSLUND Ph. D. at »Statens Skogsförsöksanstalt«, Stockholm, for the help received in the determination of various mites.

I am indebted to Mr. VERNER CHRISTENSEN, Department Geologist, who very kindly carried out the ignition loss analyses, and to Mr. PALLE KNUDSEN M.Sc. for sorting a part of the material, while I wish to express my thanks to Mr. P. GROSS, who has drawn the diagrams. And finally I acknowledge with gratitude the receipt of a grant from the RASK-ØRSTED FOUNDATION which has rendered possible the translation into English by Miss ANNIE I. FAUSBØLL, M. A.

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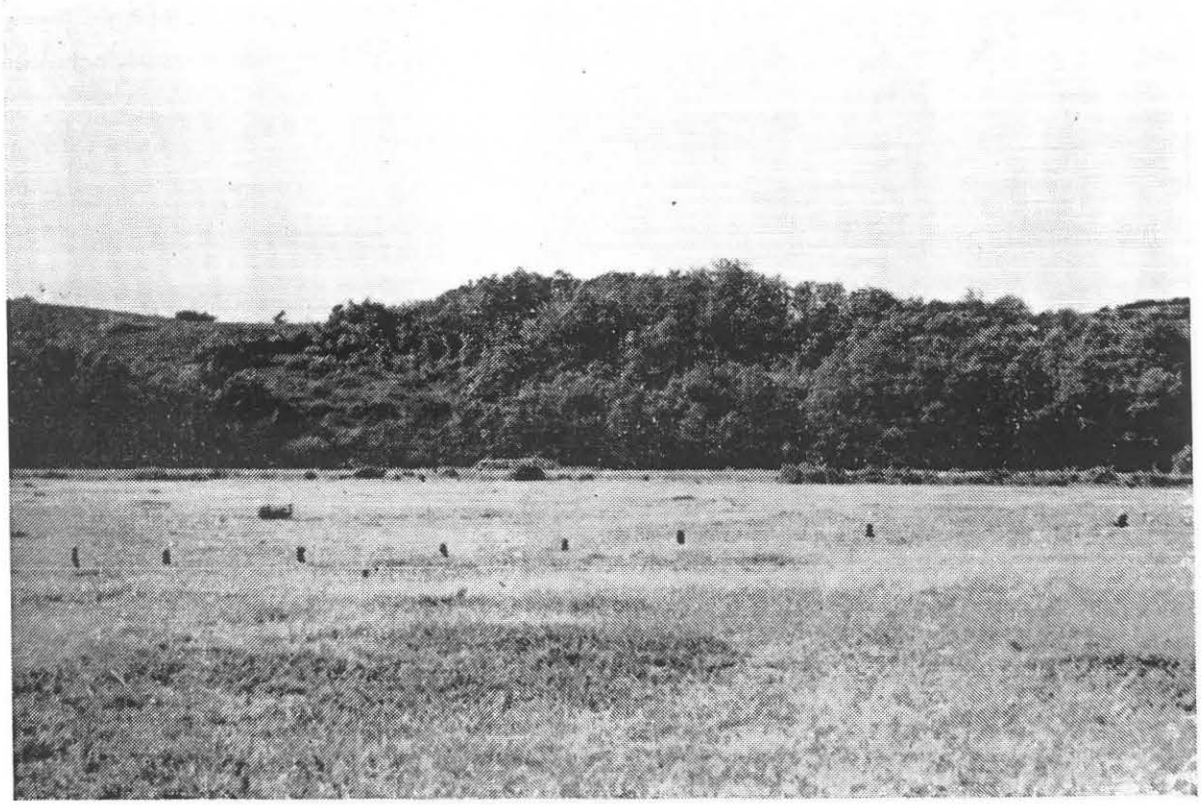

| VII | VI | V | IV | III | II | I |

Fig. 1. Sampling line, side view. In the background, the slope of the hill with an oak-beech copse. The number of each locality is given below the picture. Back, left, a heather hill. (Thamdrup phot.)

INTRODUCTION

Briefly outlined, the present investigation was carried out in the following way:

On a permanent, poor pasture called the Plain (Sletten), in the grounds of the Mols Laboratory at Strandkær near Femmøller, I marked out a sampling line (Fig. 1). Geologically the Plain must be regarded as a raised *Littorina* beach; it consists of comparatively large-grained beach sand and blown sand of a quite homogeneous character. The differences in level are very small, amounting at most to half a metre. The ground water level is high, for which reason the lower areas are regularly flooded in the cold season and have a pronounced hygrophilous vegetation consisting in great part of *Carex demissa* and *Hieracium auricula* (Fig. 10). The high-lying areas, on the other hand, have a markedly xerophilous vegetation, in which *Hieracium pilosella, Gnaphalium arenarium* and *Polytrichum piliferum* are the dominants. The slight difference in level in connection with the large grain size of the sand (low water capacity) and the constant grazing have thus been sufficient to create very different life conditions for the plants on a surface with an apparently uniform physiognomy.

On this plain I marked out a sampling line about 12 metres long and with a difference in level between the end points of only 46 cm (Fig. 1). The line extended from the dry *Gnaphalium arenarium* community through the *Agrostis-Sieglingia* community to the wet *Carex demissa* community. It was divided into 7 sections corresponding to 7 types of vegetation. Each section was called a locality and these were termed successively from dry to wet: Pl. I, Pl. II . . . . . Pl. VII. The types of vegetation recur in many other places on the Plain, but since they may occur mixed, I only employ the term plant community for the above-mentioned three communities. Each of these corresponds to a sociation (du RIETZ 1930). About once a month a series of equal-sized BERLESE samples was taken (see p. 150) from each locality except Pl. VI. In addition, supplementary samples were taken partly from other localities on the Plain partly from a meadow and a couple of heather hills close by. — A pretty careful analysis of the vegetation and soil was made, and the water content and temperature were measured at each sampling.

The aim of this investigation was to elucidate the following questions:

1. Can the same gradual changes be found in the composition of the microfauna as occurred in the vegetation, and in which strata is the microfauna concentrated?
2. What ecological factors can be conceived to be the cause of possible changes?
3. Do qualitative and quantitative changes take place in the microfauna throughout the year?
4. Are the annual changes, if any, connected with variations in the external conditions (temperature, water content)?

I have only studied the arthropod fauna, more precisely, only the arthropods which can be extracted from the soil by means of the well-known BERLESE apparatus. If no other statement is made, I employ the term microfauna about these animal forms only. In other words, I am solely concerned with the *Collembola, Acarina*, some few larvae of *Diptera*, and a few animal species not precisely determined. *Protozoa, Nematodes*, and *Enchytraea* which are no doubt in many localities of much greater importance for the metabolism of the soil I have not studied at all or only very superficially.

When I made the preliminary investigations in June and July 1942, the number of individuals per $^1/_{1000}$ sq.m amounted to about 40-50 in the various localities of the Plain, and in several places it was higher. Since animal life at this season, according to the investigations of other workers (e. g. FRENZEL 1936), is said to be comparatively poor (the minimum in February and July), I did not hesitate to use a sample size of $^1/_{1000}$ sq.m. Private considerations rendered necessary a postponement of the working up of the material until

the greater part of the samples had been collected. It was therefore an unpleasant surprise to discover that the number of individuals per unit of area throughout the winter and the first half of 1943 was considerably lower than in July 1942. The cause of this is unknown (the drought?) The numerical material is therefore too small to throw any further light on the question as to the annual variations of the microfauna. The solution of this problem requires a particularly large numerical material, the variations being chiefly of a quantitative kind.

A careful qualitative and quantitative analysis of the composition of the fauna must be of fundamental importance for every sociologico-ecological investigation. — I have considered it important to work up as large a part of the fauna as possible since the interaction between the individual groups and forms must be considered to be of great significance for the community as a whole. But it must be emphasised that the microscopic arthropod fauna only constitutes a small part of the total fauna of the soil, and is in many ways dependent on the other groups.

In many works concerned with the microfauna the description of the localities has often been imperfect. I have tried to analyse the localities of the Plain as carefully as time would allow, since the description of the habitats of the animals in the narrowest sense must form the basis of an ecological investigation of this kind. — Concerning comparisons with other investigations of this sort it is worth mentioning that during the war we had no access to the Anglo-American literature.

THE NOMENCLATURE

Systematics. For the Collembola I have used the same system and nomenclature as HANDSCHIN in his treatise of the collembolan fauna of Germany (1929). — Since there exists no similar study of the mites I have adopted the nomenclature commonly used within the various groups. As far as possible I have kept to the morphological terminology which VITZTHUM (1943) presents in his large work. The mites are arranged according to VITZTHUM's system.

The nomenclature of the vascular plants is that of RAUNKIÆR (1934).

Description of the fauna. The ecological terminology is highly controversial, and the same terms are often used in different senses. — The commonly used terms biotope-biocoenosis and biochorion-connex (FRIEDERICHS 1930 and KROGERUS 1932) are defined on an ecological basis: the definitions mention important and indispensable life conditions (see KROGERUS 1932, pg. 12). — These definitions imply that the ecological requirements and conditions are known. As a rule this is not the case, and the term biotope is usually employed in the sense »type of landscape«, while biocoenosis denotes the total world of organisms within the biotope.

The problems associated with the ecology of the terrestrial animals are in great part unsolved. This applies especially to the microfauna. Many species of collemboles and mites occur in widely different biotopes and are therefore called ubiquists or the like: but this need not mean, of course, that these species have no definite requirements, but merely that those requirements are met in biotopes of widely different character. If we examine the ecological conditions offered to the macroscopic fauna, for instance birds and mammals, in a number of biotopes, it is not a matter of course, indeed it is hardly probable, that we shall get an idea of the conditions to which the microscopical fauna is subject in the various biotopes. — Only by investigating the haunts, in the narrowest sense, of the various communities can we arrive at an understanding of the occurrence of the animals in nature. LINNANIEMI (1907) realised this when he divided the collembolan fauna into a humus fauna, a moss fauna etc. So this division is in fact based on a knowledge of the haunts of the animals.

GISIN (1943) defines the smallest collembolan societies, the synusiae, as

follows: a synusia is a body of organisms found together in clear dependence on the external conditions in the smallest section of the surroundings. This section he calls habitat (= haunt).

In setting up the various synusiae he is only guided by the composition of the fauna, the synusiae are therefore erected on a purely physiognomical basis. Thus we read in his summary: »Die Faunenlisten wurden auf Grund ihrer Übereinstimmung zu Synusien zusammengefasst und nach Art der Pflanzensociologie dargestellt und benannt«. — However, GISIN showed that, at any rate broadly speaking, these synusiae occurred in particular plant communities. GISIN's use of the term synusia is therefore well founded, as he has demonstrated a correlation between the composition of the fauna and the external conditions. — On the other hand, GISIN does not offer any definite opinion on the requirements and conditions of the individual communities, and he avoids the term »the most important and indispensable life conditions« in his definition. — Since the composition of the fauna, its physiognomy, is the primary factor in every sociological investigation, GISIN's definition of synusia and habitat is easier to use and therefore to be preferred to the terms biochorion and connex.

In the sequel the term habitat is used in the sense of the actual haunts of the microfauna. — The term synusia, on the other hand, is not employed, as the investigation is not sufficiently extensive to justify the erection of generally valid, well characterised synusiae, but the more neutral term community is used, and the term is merely meant to denote that a particular number of species is found in the same locality or type of locality in a fairly constant proportion, in contrast with a number of species differing in a qualitative or quantitative respect, occurring in another locality or type of locality.

The statistical treatment of the material merely calls for the following remarks.

The term constancy expresses the frequency of a species in the different samples from the same locality, and the degree of constancy designates the number indicating in how many per cent of the samples the species in question has been found. The species are divided into constancy classes according to the table used by KROGERUS in 1932 (p. 208) (originally BROCKMANN JEROSCH, 1907):

In more than 50 p. c. of the samples	constant species.
In from 25 to 50 p. c. of the samples	accessory species.
In less than 25 p. c. of the samples	accidental species

It must be emphasised that degrees of constancy can only be compared if the same size of sample is used, since the values will change with the size.

The term dominance expresses the relative frequency of the species in the community, and the degree of dominance is the figure indicating how many per cent of the total number of individuals the species in question constitutes. Likewise according to KROGERUS 1932 (pg. 216) (originally PALMGREN 1930, pg. 132) the fauna is divided into:

Dominant species	—	5 p. c. or more of the number of individuals.
Influent	—	5-2 p. c. of the number of individuals.
Recedent	—	2 p. c. or less of the number of individuals.

The border values have been given by KROGERUS (but not PALMGREN) without any particular motivation. It is natural that they should be so placed that a dominant species, with the size of sample used, is also constant, provided the locality is uniformly populated by the species in question.

MARIE HAMMER (1937) has used the same basis of division in her work on the microfauna of Greenland.

It should further be noted that the Americans SHELFORD, BLAKE, CLEMENT, and others use the terms dominant, influent, subinfluent, and dominule in quite another sense. Their definitions take account of the bearing and influence of the animal species on the total world of organisms in the locality.

HISTORICAL

In the last century the study of the terrestrial mites and collemboles was in the main limited to systematic investigations, and C. L. KOCH's large publication (1835—44) forms a fine introduction to the work that culminated in BERLESE's many papers in »REDIA« at the beginning of this century. While it is not intended here to enumerate the many systematic works which have seen the light of day since KOCH's time (e. g. by MÈGNIN, NALEPA, CANESTRINI, OUDEMANS, VITZTHUM, TRÄGÅRDH, THOR, BANKS, HALBERT, SELLNICK, WILLMANN, JACOT and others) there are nevertheless two workers who should be mentioned in this connection. The first is A. D. MICHAEL, whose great works »British Oribatidae« and »British Tyroglyphidae« are of great systematic value, and which — in addition to some minor papers — contain a wealth of biological and faunistic observations that form the groundwork of our present knowledge of the biology of these animal groups. Faunistic and ecological investigations have for the last few decades been in the forefront, to the great detriment of the biological researches. This is felt so much the more now that the quantitative methods have come into use, statistics being able to describe but not to explain the faunistic observations made in nature. — The second is the Finlander LINNANIEMI who in 1907—12 published the work, now soon a classic, »Die Apterygotenfauna Finnlands«, which as far as the biology is concerned cannot be compared with MICHAEL's Oribatid investigations, but whose strong point is partly the systematics, partly the circumstance that LINNANIEMI was the first to attempt successfully a division of the collembolan fauna into communities according to their habitats.

While the use of the BERLESE apparatus led to the discovery of many new species and initiated a better investigation of the mite and collembolan fauna of many countries and landscapes (TRÄGÅRDH, HULL, SCHWEIZER, VITZTHUM, THOR, THAMDRUP, WILLMANN, SELLNICK, and others) automatic driving-out apparatus were first used in the service of quantitative ecology at the close of the twenties. In his thesis for the doctorate FORSSLUND (1943) has given an excellent historical account of the development of the quantitative investigation of the soil fauna, and in the following only the chief quantitative works relating to the mite and collembolan fauna will be mentioned.

Cameron, Morris, and Buckle are well known for their works on the arthropod fauna of arable land (Rothamsted Experimental Station). Of special interest is a paper by Morris (1927) showing that areas manured with stable manure have a considerably richer animal life than the corresponding unmanured soil or soil manured with artificial fertilizers. — In North America Jacot has made many investigations on the terrestrial microfauna (especially the *Oribatidae*), but only a few of his works are available in Denmark. His paper »Soil Structure and Soil Biology« 1936 forms a fine parallel to Kubiena's (1932 and 1938) micropedological investigations, both these enquirers pointing out the necessity of a closer study of animal life in the untouched soil. The details of Jacot's paper are controversial.

The only quantitative investigation relating to the Danish microfauna is Bornebusch's publication on »The fauna of the forest soil« (1930). He points out the great difference there is between the fauna of raw humus and of mould.[1]) Volz has described the collembolan fauna partly in a raw humus partly in a mould locality, and likewise found a marked difference. He has besides divided the fauna into surface and underground forms, and Gisin's life form system is a further development of Volz's ideas. Volz also points out the importance of pore volume determinations, but does not apply his results to the fauna.

Marie Hammer has set up two communities for Greenland, a dry soil and a moist soil community, both characterised by a couple of *Oribatidae*. Her publication deals both with mites and with collemboles (1934, 1937, 1938 and 1944). — Frenzel's (1936) very extensive investigation on the fauna of meadow soil treats nearly all animal groups and contains much important faunistic information, but unfortunately does not warrant such far-reaching ecological conclusions as was at first to be expected. — Ford (1937) has examined the microfauna of grass tufts and found that it differed considerably from the microfauna which is to be found on the surface or in the upper layers of the soil. — Glasgow (1939) investigated the distribution of various subterranean collemboles within a small area and found that the species *Onychiurus armatus* and *O. ambulans* as well as *Tullbergia krausbaueri* and *T. quadrispina* all occurred in colonies, and that these colonies had a different size which depended on the species. — Baweja (1939) investigated the fauna of sterilised soil and found that after 4-7 months it had attained the same density of individuals as the control localities. But he observed that the increase continued and that after a year the number of individuals had risen to about double that of the control localities. In addition he found a considerable

[1]) Bornebusch's work besides that of Thamdrup (1932) is the only paper dealing with Danish soil mites.

maximum in the autumn and early winter. — In 1941 AGRELL issued his work on the ecology of the collemboles. The investigations on the temperature reactions of the collemboles, their responses to humidity, and their breeding periods are especially important. — GISIN's paper (1943) will be discussed again later. His review of the individual species is of great interest, but it is of special significance that GISIN finds a distinct correlation between collembolan and plant communities. TUXEN (1943) in a short article gives an account of the composition of the oribatid fauna and its dependence on the humidity conditions in 5 localities in northern Iceland among which he finds distinct differences. Finally we may briefly mention FORSSLUND's large and very thorough work on the fauna of north Swedish forest soil; but as the article did not come to Denmark until the close of December 1943, unfortunately it could not have any great influence on this work.

If we survey the results that are of interest in this connection our present knowledge of the terrestrial microscopic arthropod fauna may be briefly summed up as follows:

1. The fauna consists chiefly of *Collembola, Gamasidae, Trombidiformes, Oribatidae,* and some few *Tyroglyphidae* and *Diptera* larvae (especially *Chironomid* larvae).

2. The qualitative and quantitative composition of the fauna would seem to depend on and be characteristic of the types of localities, but the question as to the dependence of the fauna on the surroundings is far from cleared up yet. This problem has especially been investigated for the *Collembola* and the *Oribatidae* (LINNANIEMI, HANDSCHIN, VOLZ, GISIN, WILLMANN, TUXEN, and FORSSLUND). Further the quantitative proportions vary between the different groups (TRÄGÅRDH, FRENZEL, HAMMER, and FORSSLUND). The humidity conditions seem to be of decisive importance for the composition of the microfauna (FRENZEL, HAMMER, TUZEN, and GISIN). The actual causes of the different distribution of the animals in nature are, however, unknown. The investigation of the *Gamasidae* and the *Trombidiformes* falls far below that of the other groups. The collemboles have in every respect been most thoroughly investigated.

3. The occurence of the animals in the individual localities is not uniform (GLASGOW and FORSSLUND); this applies especially to localities that have not attained a »biological equilibrium« (FORSSLUND); the density seems to be connected with the conditions of nutrition.

4. In a quantitative respect the fauna is subject to great fluctuations manifesting themselves in an autumn maximum and a summer minimum (FRENZEL and BAWEJA). Only the breeding conditions of the collemboles (AGRELL 1941) and some few oribatids (HAMMER 1937) are fairly well known.

5. Very little is as yet known about the interaction of the individual groups and their relation to the rest of the fauna.

METHODS

In this section we shall describe the method adopted in taking the samples, in analysing the vegetation and soil, and in the sorting and determination.

Sampling. As previously stated, a series of samples were taken at intervals of well over a month from each of the 6 above-mentioned localities. Each series consisted of 5 samples of 10 c.c. each. A series was taken in the following way: By means of a steel cylinder, a soil-sampling tube, with a lumen of 10 sq. cm $= \frac{1}{1000}$ sq. m, a soil sample 5 cm long was taken up, i.e. 50 c.c. in all. The sample was taken vertically from the surface down to a depth of 5 cm. It was then laid on a piece of paper divided into centimetres and cut with a sharp knife into 5 equally large transverse slices, the 5 samples. These were labelled and put unbroken each into its own glass tube. In collecting animals for experiments a tool with a lumen of $\frac{1}{100}$ sq. m. was used.

Note. The tool is about 15 cm long and made of stainless steel. It is important when taking samples in sticky soil or raw humus that its lower edge should be sharp. It should be noted that the depth to which the tool has descended in the soil should always be read on the outside of the cylinder. — With a pestle corresponding to the lumen, the sample may with a little care be pushed undamaged onto the paper.

Separation and further treatment. The animals were separated from the soil in a large BERLESE apparatus (fig. 2) consisting of 15 zink funnels surrounded by a large common warm-water jacket. Part of the time the apparatus was stationed at the Mols Laboratory and part of the time at the

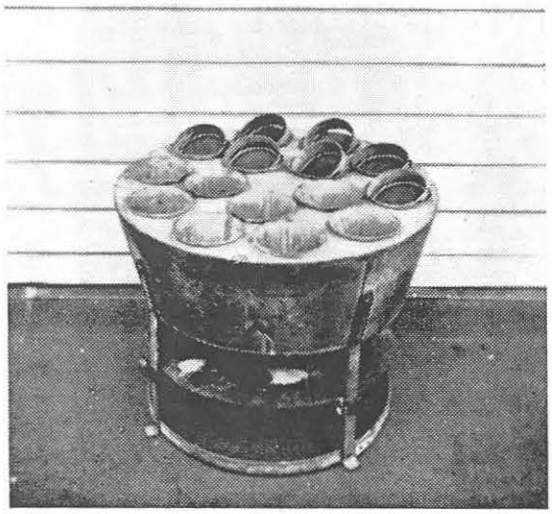

Fig. 2. BERLESE apparatus.

Natural History Museum in Aarhus. The samples from Pl. I, IV and VII were treated immediately after they had been taken, whereas the samples from Pl. II, III and V had generally been lying 4 or 5 days before treatment. Each sample was laid in a small sieve and the sieve with the sample was weighed before and after sifting. This was done at a temperature in the sieves of about 35° C., and the samples were treated for 4 or 5 days. Beneath each funnel was placed a glass tube containing a mixture of glycerine and 70 p. c. alcohol (1:10, as recommended by TRÄGÅRDH (1932)). The tubes can be kept for an unlimited time.

Note. Of recent years, instead of the ordinary Berlese apparatus described here, Tullgren's modification is generally used, where the driving out takes place by the combined action of desiccation and light. Trägårdh described and tried this method in 1932: but he made no somparison between this and the earlier apparatus. — As there is as yet no electricity laid on in the Mols Laboratory, I was obliged to use the ordinary Berlese apparatus.

The samples af raw humus (Rogeshøj) contain about 300 animals per $\frac{1}{1000}$ sq. m and the BERLESE apparatus may therefore be regarded as satisfactory. Further, the smallest known forms such as the *Brachychthonius* and *Nanorchestes* species were frequently found both as adults and nymphs.

The samples were not sifted in the natural conditon but were spread carefully out in the sieves in a layer 1/3 to 1/2 cm thick. On the bottom of the sieve was laid a piece of extra fine netting. This prevented the earth from dropping into the glasses. JACOT (1936) has advocated treatment of the samples in their natural condition. His results, however, do not seem to indicate that his method is more suitable. On the contrary, the number of animals per unit of area is much smaller than might be expected, and the yield of nymphs and larvae is slight.

The sample must be treated with care and must not be pressed or shaken. The damage such treatment may cause can be directly observed for instance when samples from forest soil are dealt with, many *Collembola* being then fatally injured.

After drying, each sample of soil was put into a labelled paper bag with a view to later analyses.

Measurement of the water content of the soil. As already mentioned, each BERLESE sample was weighed before and after treatment, the desiccation in the BERLESE apparatus being so complete with these sandy soils that the loss of water in the samples can without any great error be used to calculate the water content of the different layers. This is shown by the following analysis: 3 samples from Pl. II, III, and V were first dried in the usual way and the loss of water computed. Then they were placed in a thermostat at 110° C. The additional loss of water in grammes is given in the table below.

	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm
Pl. II	0.12 g	0.08 g	0.05 g	0.04 g	0.07 g
Pl. III	0.13 g	0.05 g	0.13 g	0.05 g	0.00 g
Pl. V	0.14 g	0.08 g	0.07 g	0,15 g	0.00 g

Since the samples in layers 1-5 cm weigh 12-16 grammes, the error in these layers is not more than 1 p. c. It must be emphasised that small variations in the water content may have a great influence on the relative humidity in the pores of the soil (THAMDRUP 1939); but since this work is of a preliminary character I have not determined the water content with any great accuracy.*) Analyses of the correlation between the water content and the relative humidity (vapour pressure) in the pores of the soil have been carried out by Mr. KOIE and he has kindly let me have some of his figures. I did, however, make a few measurements with a »Steck hygrometer« (THAMDRUP 1939 pg. 14) in the warm period in 1943.

To render possible a comparison of the above-mentioned water percentages with the values with which botanists usually operate and to get an impression of the water supply altogether, I have also determined the water percentages in samples taken specially with this object in view. From each locality there were at the same time as the BERLESE samples taken 2 samples with the soil-sampler, one from 0-5 cm and one from 5-10 cm. These samples were dried in a thermostat at 110° C.

Measurement of the precipitation. Daily measurements were made during the whole period of the investigation. A common standardised rain gauge was used, set up on an exposed hill top about 1 km from the Plain.

Measurement of the ground water level. In the localities Pl. I, V, and VII the ground water level was measured at each sampling. A concrete tube with a collar and metal lid which projected above the surface was dug down in these localities, and the water level could be measured simply by means of a plummet. — The very dry spring in 1943 caused the wells to dry up during the summer.

Measurement of the temperature. During the sampling the temperature was measured in the soil of each locality at a depth of 1-2 cm. Originally it was intended to set up constantly a combined thermohygrograph. The war, however,delayed the delivery of the apparatus.

Analysis of the content of organic matter in the layers. The

*) As another source of error may be regarded the circumstance that a little earth will always drop through the funnel: but this can mostly be prevented by the use of double netting.

analyses were kindly undertaken by »Danmarks geologiske Undersøgelser« (The Geological Survey of Denmark) as ordinary analyses of ignition loss. Since the soil does not contain lime or clay the ignition loss corresponds approximately to the content of organic matter. — The samples used were the ordinary BERLESE samples and from each of the localities Pl. I, IV, and VII 5 series were analysed, from the rest only 1 series.

Analysis of the root content in the layers. So as to form an idea of the size of the root layer and its share in the the total amount of organic matter in the various layers I made a quantitative analysis of the root system. 2 series from each of the localities Pl. I, IV, and VII were examined. The samples were taken with the soil-sampler, like the ordinary BERLESE samples. Each sample was laid on a fine-meshed wire net and thoroughly washed by means of a strong syringe. The water jet had to be very strong to wash out the sand and organic remains from the samples from the wet part of the Plain. An examination of the waste water showed that only a very small amount of roots was pressed out through the wire net. The washed root sample was laid in a Petri dish with water and the coarser roots were sorted from the root fibres. In the surface samples it was further necessary to distinguish between dead and living components. — All the samples were put in paper parcels and dried for about 24 hours in a thermostat at 100-110° C. They were then weighed partly on a torsion balance, partly on a common damped analytical balance with an accuracy of 1-2 mgr. It must be pointed out that both the paper parcels and the contents very quickly absorb moisture in an atmosphere with ordinary relative humidity. It is necessary, therefore, to keep the samples in an exsiccator while cooling. — In this way the root content can be found in 10 c. c. of earth. In order to calculate how large a proportion of the dry weight of the earth the root mass constitutes, it must be ascertained how much 10 c. c. of earth weighs in the dry condition. This figure is obtained by taking the average of the dry weights of all the BERLESE samples.

Analysis of the vegetation. The analysis of the vegetation was performed according to RAUNKIÆR's circling method (1909). In each vegetation type 10 circular plots were marked out with a metal frame of 1/20 sq. m. The frequency percentage of a species denotes in how many per cent of the circular plots the species in question has been found.

Levelling. Levelling was carried out by drawing a tight horizontal cord between two strong poles at the end points of the line and measuring the distance from this to the surface at every half metre. The difference in level, 46 cm, was verified with a level.

The hydrogen ion concentration. pH determinations of the soil were made at various depths. A ionometer was used with a glass electrode (LA-

DELL's type). The samples were analysed directly after being taken. Only a preliminary analysis was made.

The mechanical analysis of the soil. The analyses were carried out by Mr. KØIE. My grateful acknowledgements are due to him for letting me use his experimental results. He determined the volume weight, pore volume, and specific weight, as well as analysing the grain size of the soil at a depth of 5-8 cm. The measurements of the former values were made by the pycnometer method, the measurement of the latter by means of a combined sifting and pipetting method.

Methods of sorting and determination. The stoppered BERLESE samples were turned upside down once or twice, the stopper taken out, so that the contents could fall into a small, flat, squared dish (7×7 cm). The stopper was rinsed and the tube shaken with alcohol. The importance of this procedure is emphasised by FORSSLUND (1943, pg. 81).

The sorting was done under a binocular microscope by means of a fine pipette: the sample was gone over twice, first at a magnification of 24, then at 40 times' magnification. The animals were transferred directly to a concave slide or a watch glass containing 60 p. c. lactic acid. If the material was to be determined at once, the lactic acid was warmed a little, and the clearing of the animals controlled under the microscope. Even the most delicate animals will tolerate a stay in the cold acid for a long time. The identification of the small *Trombidiformes*, the *Oribatidae*, and some *Collembola* requires a high magnification, and it has been necessary, therefore, to prepare the greater part of the material. Through alcohol and glycerine the animals were transferred to glycerine-gelatine or mounted directly in lactic acid. — All the preparations were provided with small wax feet of plastilin. In this way it is possible partly to place the animals to advantage on the slide, and partly to turn them about as one likes by little pushes on the edge of the glass.

In some cases it was impossible to identify the animals with such as had hitherto been found.

A few scattered observations on hatching and feeding of a more general character were made, the following method being adopted: the animals were put into small cages made of a slide onto which a ground glass ring had been glued with Canada balsam (HANSEN's rings for moist chambers). The inner, lower edge of the ring was provided with a low plastilin wall; a piece of moist cotton wool was laid at the bottom and a wet trimmed piece of paper (black or white) was laid over and pressed down firmly against the plastilin wall. The animals were placed on a substratum of earth, algal vegetation, and the like, in the middle of the cage, and the latter was closed with a round cover glass. The cover glass was kept in place by a small metal clip fastened

to the ring by means of a small piece of elastic. — The cover glass was very easily taken off and put on, and the small irregularities allowed an exchange of air between the cage and the surroundings. The cotton wool at the bottom kept the cage suitably moist for several days at a normal temperature, and prevented the water from gathering in drops on the glass when »the animals were watered«. From a large metal sandwich box with drawers I made a travelling case (Fig. 3) that would take 50-70 cages. The cages were kept in place by means of small removable frames. The case was very serviceable on journeys.

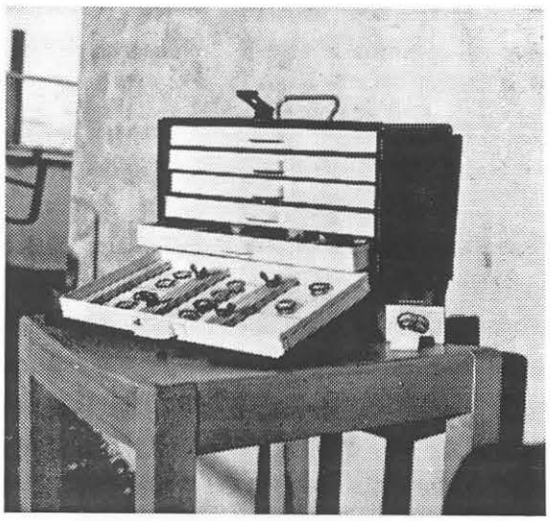

Fig. 3. Travelling case.

DESCRIPTION OF LOCALITIES

STRANDKJÆR AND THE »MOLS LABORATORY«

As already mentioned, the investigation was made in the grounds of the Mols Laboratory at Strandkjær, a couple of kilometres to the south of Femmøller.

The Laboratory was opened in May 1942. The grounds extend westward about 2 km inland from the northwestern corner of the bay Ebeltoft Vig. It comprises in all 550 acres of land, of which 100-140 acres are cultivated. Geologically it consists of two areas. Immediately along the beach there is a large flat area, a raised littorina beach over which the Plain already mentioned extends. From the east westward this part consists of the following types of landscape: strand, strand-meadow, Myrica bog, oak scrub, plain, and meadow with alder and ash groves (for further description, see THAMDRUP 1948).

The flat area is very sharply marked off from the old coast line which is characterised by large slopes and steep hills. The hills belong to the eastern part of large marginal moraine formations. Their content of clay and sand is therefore highly variable. The uncultivated area is a reservation, preserved unused mainly as heather hills and plantations. Characteristic of the heather hills are the many large junipers *(Juniperus communis)* and the bilberry bushes *(Vaccinium myrtillus)* on the northern slopes.

The description of the localities comprises two sections:

1. Description of the Plain and the sampling line.
   a. General description with vegetation analysis etc.
   b. Description of the habitats.
2. Description of the rest of the localities: the meadow, the southern meadow, Rogeshøj, and Revlinghøj.

THE PLAIN AND THE SAMPLING LINE

DESCRIPTION OF LOCALITIES

The Plain at first sight seems very uniform. The differences in level hardly exceed 1 metre, and the plain may be characterised as a smooth sandy area, the highest parts of which must be regarded as old beach ridges when they contain stones, or low dune formations when the sand is without stones. The

sand is throughout of the same composition, about 90 p. c. having a grain size of between 0.6 and 0.2 mm and only containing 1 p. c. of dredgeable constituents (0.002) (see Table 4). This is precisely the composition characteristic of blown sand. ATTERBERG (1903, pg. 400) calls sand of this size of grain »ordinary sand«. He gives the following characterisation of it: Order of size 0.5-0.2 mm; capillarity 25 cm (i. e. the water in the microcaverns can be raised to a height of 25 cm from a free water level). Showers less than 30 mm can be retained in the upper strata of the soil but sink slowly. Heavier showers sink more quickly and cannot be raised by capillarity. — The table below, which Mr. KØIE has kindly let me have, gives details of the composition of the soil in Pl. I at a depth of 5 cm. Other investigations from the Plain prove that the soil in other parts of it must be supposed to have the same composition.

Sifted:		Dredged:	
2.0 - 0.6 mm	0.8 p. c.	0.06 - 0.02 mm	0.4 p. c.
0.6 - 0.2 »	90.7 p. c.	0.02 - 0.006 »	0.2 p. c.
0.2 - 0.1 »	6.8 p. c.	0.006 - 0.002 »	1.0 p. c.
0.1 - 0.06 »	0.4 p. c.	< 0.002 mm	0.7 p. c.

In an agricultural respect the Plain must be characterised as a permanent pasture and throughout the vegetation period it is used for grazing purposes. The result of this is that the annual addition of organic substance to the soil is very small. Earthworms do not occur at all in the dry part in the summer, and only sparsely in the wet part. — More than 30 years ago it was under the plough. In my sampling areas there was not the slightest trace of previous ploughing left. — The presence of oak scrub and heather shows that left to itself the Plain would slowly be transformed first to areas with heather and pools, and then to oak scrub copses with *Myrica gale* bogs.

The sampling line (Fig. 1) is laid in the middle of the Plain in the direction NW-SE. The line must be regarded as a moisture sequence; the soil as we move from its higher to its lower part grows gradually moister and differences in the water content have originally been the only differences between the localities: but the soil now differs essentially in the high and the low areas.

The vegetation analysis.

The differences between the localities being most plainly marked in the vegetation, we shall first describe this. In the erection of vegetation types the following factors have been taken into account:

1. The qualitative composition of the vegetation. (Circling).
2. The quantitative composition of the vegetation (degree of covering and thickness). Based on estimation.

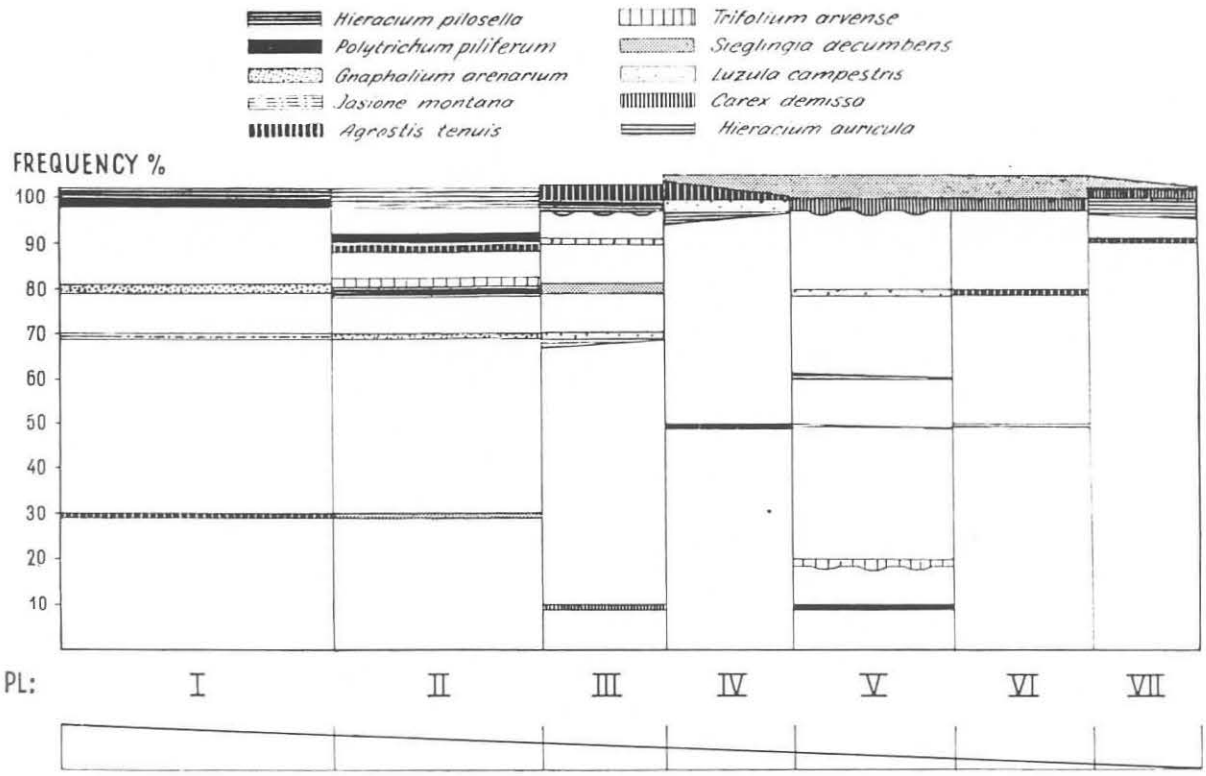

Fig. 4. Vegetation anlysis.

It may seem a questionable procedure to set up 7 types of vegetation within so small an area, and a botanist would indeed only distinguish between three plant sociations (in DU RIETZ's sense (1932, pg. 307)): a *Gnaphalium — Agrostis* sociation, a *Sieglingia* sociation, and a *Carex demissa* sociation. The lines of demarcation between the individual types or zones of vegetation are however so clear, that in marking out the boundaries I was in no doubt as to their placing, and since it is precisely the object of this work to ascertain whether the gradual change in the external factors results in a gradual change in the composition of the animal fauna, I have chosen the finer division.

The results of the vegetation analysis are shown in Table 1. The frequency percentages of each species are given. The chief results are summed up in the diagram Fig. 4. Below is seen a profile of the sampling line. The frequency percentages are given as the ordinates, and the character species in the various localities are represented by a horizontal zone. The width of the zone denotes how great a share the species in question is estimated to have in the mass of vegetation in question. If the zone is horizontally striped it denotes that the growth form of the species is horizontal; if the zone is vertically striped it means that the growth form is vertical. A scalloped zone denotes that the species occurs in spots; if it tapers it means that the species in question is decreasing in number.

A horizontal growth form is no ordinary botanical concept. By this

Table 1.

Species \ Localities	Pl. I	Pl. II	Pl. III	Pl. IV	Pl. V	Pl. VI	Pl. VII
	%	%	%	%	%	%	%
Sieglingia decumbens		30	80	100	100	100	100
Agrostis tenuis	30	90	100	100	100	80	90
— *canina*	70	60	10				20
— *stolonifera*	5						
Festuca ovina	30		20				
Corynephorus canescens	10						
Holchus lanatus					10		
Anthoxanthum odoratum		few	few				
Carex demissa			few		100	100	100
— *panicea*					10	40	
— *leporina*						10	
— *stolonifera*					few	few	
Juncus squarrosus						30	10
Luzula campestris	few	few	70	100	80	50	20
Gnaphalium arenarium	80	70					
Hieracium pilosella	100	80	100	100	60		
— *auricula*					50	50	100
Leontodon autumnalis					60	20	90
Jasione montana	70	100	70				
Hypochoeris radicata		few	70	30		20	
Achillea millefolia			30	80	100	50	
— *ptarmica*					90	100	80
Brunella vulgaris				50	100	100	80
Mentha arvensis						10	
Euphrasia stricta		10	60	60	60	10	
Veronica officinalis					40	10	
— *serpyllifolium*							
Trifolium arvense		80	90		20		
— *repens*				10		50	50
— *minor and procumbens*		few	40	10		10	
Potentilla argentea	few	20		10			
— *erecta*					10		
— *anserina*						30	20
Ranunculus acer						10	
— *bulbosus*			10		20		
Scleranthus perennis	40	40					
— *annua*	50	100					
Rumex acetosella	90	100	60	30			
Cerastium caespitosum					10		
Calluna vulgaris		10	50	40		10	
Erodium cicutarium	30	10	10				
Radiola linoides		few	40	40	20		
Centunculus minimus				10	10		
Plantago lanceolata		20		few	20		
Polygala vulgaris			40	50			
Viola tricolor	few	few					
Galium harcynicum					10		
Polytrichum piliferum	100	90	100	50	10		
Stereodon cupressiforme	20	70	50	70	70		
Scleropodium purum			20	10	10		10
Dicranum scoparium				40	70		
Hylocomium squarrosum						20	80
Acrocladium sp.						80	90
Cladonia silvatica	50	80	70	10			
— *chlorophaea*	90	60	70	30			
Peltigera canina	30	50	40	10			

Fig. 5. Close-up picture of the vegetation on Pl. I. In left lower corner, a tuft af Festuca ovina. Dominant are: Hieracium pillosella and among these Polytrichum piliferum. Gnaphalium arenarium, Scleranthus species, and the scattered Agrostis plants are characteristic. (Thamdrup phot.)

Fig. 6. Pl. II. Close-up picture of vegetation. It is distinctly seen that the vegetation is denser than on Pl. I. Agrostis tenuis being especially conspicuous, though it does not form a close carpet. Dominant: Small rosettes of Jasione montana, Agrostis tenuis, Polytrichum piliferum (at A) and Hieracium pilosella. Trifolium arvense (at B) and Gnaphalium arenarium are characteristic. (Thamdrup phot.)

Fig. 7. Pl. III. Close-up photo of vegetation. The growth is closed. Agrostis tenuis, now occurring as a fairly vigorous grass growth, dominates. Holes in the Agrostis vegetation are filled up with Hieracium pilosella, Sieglingia decumbens, and Festuca ovina. — Polytrichum and Gnaphalium occur scattered and disappear towards Pl. IV. — In the centre are seen a couple of rosettes of Hypochoeris radicata and a few branches of Cladonia silvatica. Below, a match (5 cm). At left edge a sampling hole ($= {}^{1}/_{100}$ m²). (Thamdrup phot.).

Fig. 8. Pl. IV. Close-up photo of vegetation. It is seen that we have now reached the dense Sieglingia — Agrostis vegetation (Sieglingia with a heavy thick top and Agrostis with a fine thin top). — Here Brunella vulgaris is first encountered. Polytrichum and Cladonia occur very sparsely. Left, a rosette of Plantago lanceolata. (Thamdrup phot.).

term I mean that the assimilating organs of a plant are spread horizontally over the ground, while the stem is quite short or creeping (e. g. rosette plants and *Pelligera canina).* A vertical growth form means that the main axis of the plant is long and vertical; thus the assimilating organs are raised above the surface of the soil (e. g. grasses and *Cladonia silvatica).* The free surface, i. e. the surface between the stems, is relatively large in a vegetation consisting of plants with a horizontal form of growth, whereas it is essentially smaller in a dense vegetation consisting of plants with a vertical form of growth, and the air volume affected by the vegetation is here considerably greater.

The individual localities may briefly be characterised as follows (see the photographs and the appended text):

Pl. I.: Fig. 5. The Gnaphalium vegetation. The vegetation does not form a continuous cover. *Hieracium pilosella* is the dominant species and has the horizontal growth form. The interspaces are in the main filled up with *Polytrichum piliferum* and primary thalli of the *Cladonia* species which hold the sand together. Characteristic feature: *Gnaphalium arenarium* occurs scattered, *Festuca ovina* in tufts at 20-50 cm distance. *Scleranthus annua* and *Agrostis canina* are frequent but in small specimens, *Pelligera canina* and *Stereodon cupressiforme* scattered.

Pl. II. Fig. 6. The *Jasione* vegetation. Covers the ground but forms no continuous carpet, plants with a mainly horizontal growth being dominant: *Jasione montana, Hieracium pilosella,* and *Polytrichum piliferum. Agrostis tenuis* is gaining ground. *Trifolium arvense* is characteristic.

Pl. III. Fig. 7. The *Agrostis* vegetation. The dominant species, *Agrostis tenuis,* has a vertical growth and forms a thin, patchy carpet. *Hieracium pilosella* and *Polytrichum piliferum* are decreasing towards Pl. IV. *Gnaphalium* has disappeared, and *Sieglingia decumbens* appears for the first time.

Pl. IV. Fig. 8. The *Sieglingia-Arostis* vegetation. *Sieglingia decumbens* and *Agrostis tenuis* form a thick continuous grass carpet, and towards Pl. V. the soil is so thickly matted with roots that the upper layers are woven together to a firm cake, a sod. — *Luzula campestris* frequent; *Hieracium auricula* and *Brunella vulgaris* are met with for the first time, while *Polytrichum* and *Cladonia* are disappearing. Altogether the moss vegetation is very poor, it is only represented by small *Dicranum* plants.

Pl. V. and **Pl. VI.** Fig. 9. The *Sieglingia-Carex demissa* vegetation. The diagram and the table will show the difference betwen Pl. V and Pl. VI; but since the deviations are comparatively small, I have later classed them under the same vegetation type and only taken samples from Pl. V.

In association with *Carex demissa, Sieglingia* here forms a thick and dense

Fig. 9. Pl. V. Close-up photo of vegetation. Sieglingia still forms a thick grass carpet with green turf; but here Agrostis tenuis has been much reduced and superseded by Carex demissa, which is dominant and characteristic. — Brunella vulgaris (at A) and Achillea millefolia (at B) occur freqently and in fairly vigorous specimens. Achillea ptarmica appears for the first time. (Thamdrup phot.).

Fig. 10. Pl. VII. Close-up photo of vegetation. The most moist, often flooded, locality. The grass carpet is thinner and consists mainly of Sieglingia and Carex demissa. In addition, Agrostis tenuis has again gained ground. Hieracium auricula is dominant and covers large parts of the soil, and plants with a horizontal growth have thus again gained access. Hylocomium squarrosum is very frequent. (Thamdrup phot.).

vegetation carpet with green turf. *Agrostis tenuis* has been entirely crowded out. *Brunella vulgaris* appears in patches everywhere. *Hieracium auricula* is thrown much into the background in the dense vertical vegetation. *Dicranum scoparium* is found in several places in small tufts. *Achillea ptarmica* is seen for the first time, *A. millefolia* occurs in fairly vigorous scattered specimens.

Pl. VII. Fig. 10. The *Hieracium auricula* vegetation. Now once more we have a vegetation in which a plant with a horizontal growth is the dominant. (The photo does not give a very good impression of this, however). The comparatively thin patchy grass carpet consists of *Sieglingia, Carex demissa,* and *Agrostis tenuis.* The vegetation forms green turf with a dense root content. Of mosses *Hylocomium squarrosum* may be mentioned. The locality is often flooded in the cold season.

Summary: According to SEGERSTAD (1935) by far the greater part of the plant species mentioned are hemerophilous and eurytrophic, a few less important ones are stated to be eutrophic *(Potentilla anserina, Ranunculus acer, Mentha arvensis* and *Agrostis stolonifera),* while *Calluna vulgaris* is said to be oligotrophic. — The majority of the species are stated to be indifferent or acidophilous; but otherwise it may be said that the pH requirements of the individual species are little known.

Many of the plants from Pl. V, VI and VII are characteristic of the supralittoral zone, the moist and the semi-moist meadow, and thus dependent on the ground water. As will be shown later, a distinction may be drawn between an area dependent on and one independent of the ground water. The limit is at the lower part of Pl. IV.

Levelling and profiles:

A profile of the line is seen in Fig. 11. The three wells on Pl. I, V and VII, the root-bearing layer, and the height of the ground water at various times are marked. — It is seen that the line falls quite gradually, but while passing downwards the vegetation zones decrease in width.

In localities Pl. I, II, IV, V and VII profile holes have been dug. Fig 12 shows the result. Every profile hole is represented by a column with signatures

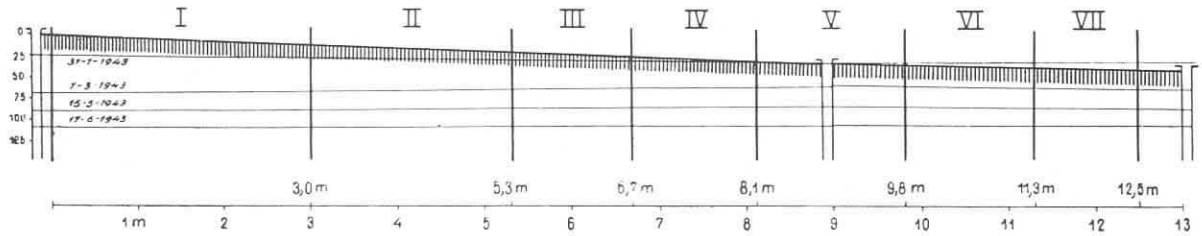

Fig. 11. Profile of the sampling line. Wells. Limits of localities. Ground water level. Root-bearing lyaer.

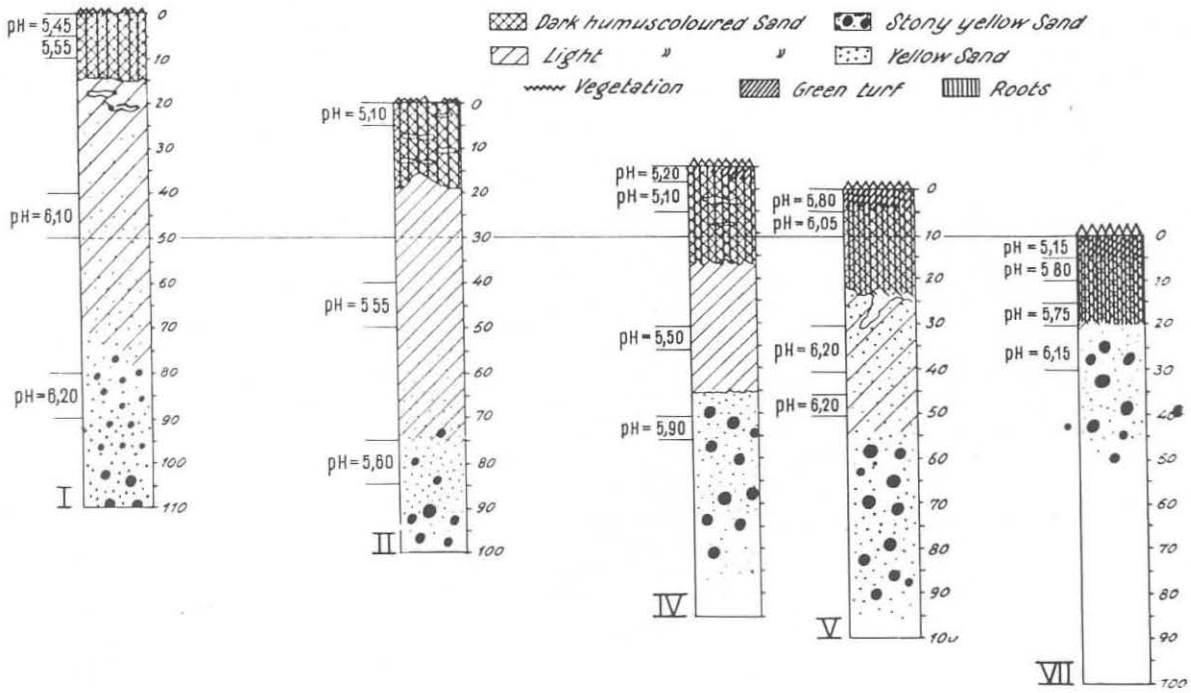

Fig. 12. Profile holes.

marked in it. The columns are placed on a longitudinal profile of the line at the appropriate relative distances.

Summary: The soil has throughout single grain structure (RAMANN 1911). Crumb structure nowhere occurs.

In the localities three strata may be distinguished:

1. Lowermost: stony, yellow, aquiferous sand with a nearly horizontal surface.
2. The middle layer, consisting of light, humus-coloured sand devoid of roots; its humus content and thickness decrease towards Pl. VII. It is chiefly in this layer that the ground water movements occur.
3. The uppermost layer consists of dark, sandy soil containing humus which is interwoven with roots. Its magnitude is as a rule 20 cm. The content of roots and organic matter is considerably increased towards Pl. VII.—Pl. I: poor and dry sandy soil, poor in roots. Pl. IV: Heavy sandy soil with a grass carpet, rich in roots. Pl. VII: Loamy, sandy fen soil with a vigorous net of roots. — The roots do not in any locality go further down than 20 cm.

The hydrogen ion concentration.

The pH was measured in the various layers. It should be noted that the values from Pl. I are probably too high, Mr. KOIE having found a pH value of 4.7 in the layer 5-8 cm. — Otherwise no great weight has been attached to pH measurements, as I accept FRENZEL's view (1936, pg. 11): »Sie ist vielmehr das Resultat physikalischer, chemischer und biologischer Geschehnisse«. The reader is further referred to FRENZEL's discussion.

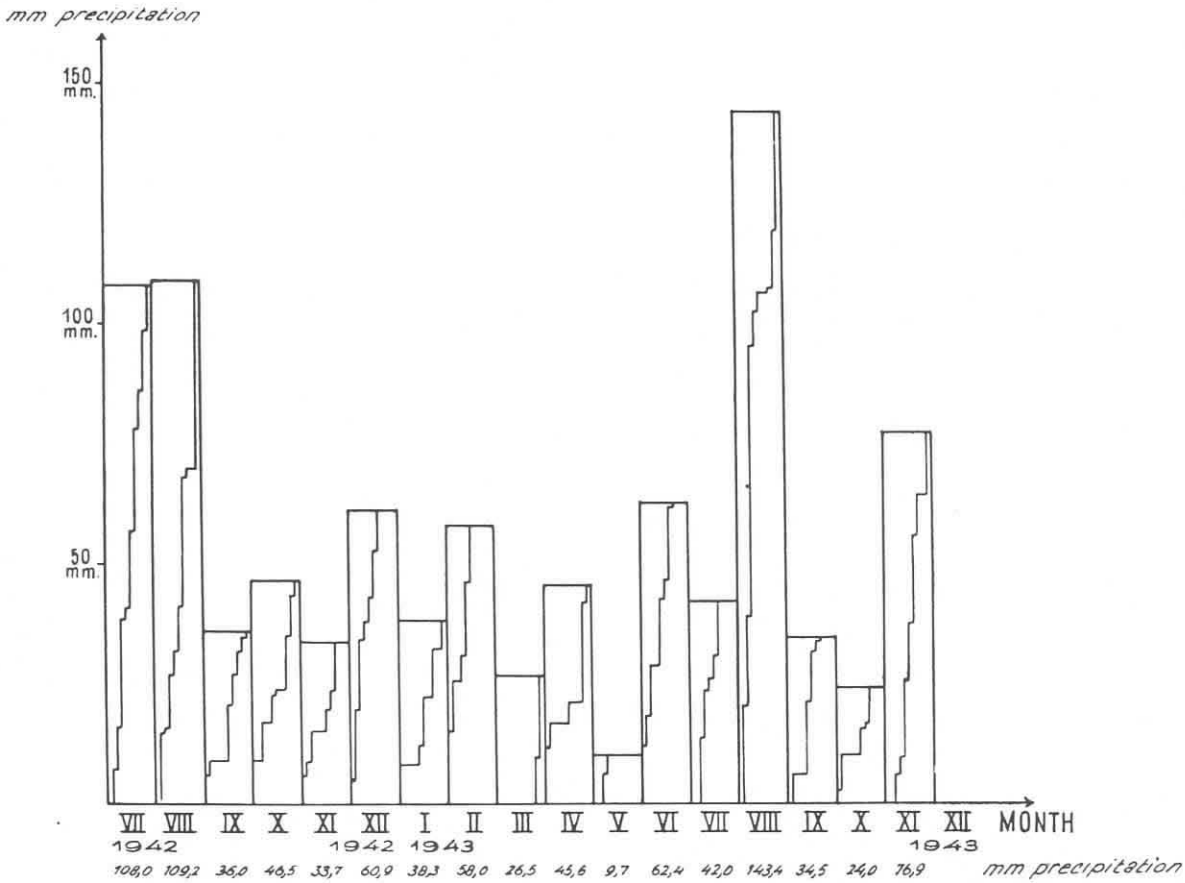
mm precipitation
150 mm.
100 mm.
50 mm.
VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI XII MONTH
1942
1942 1943
1943
108,0 109,2 36,0 46,5 33,7 60,9 38,3 58,0 26,5 45,6 9,7 62,4 42,0 143,4 34,5 24,0 76,9
mm precipitation

Fig. 13. Distribution of the precipitation in the period of investigation.

The ground water and the precipitation.

Mols is one of the areas of Denmark with the lowest precipitation. — The average annual rainfall is c. 575 mm.

Fig. 13 shows the distribution of the precipitation in the period of investigation. The monthly amount of precipitation is represented by columns. Within each column is drawn a »stepped curve« showing the distribution of the precipitation within the individual months. The procedure is as follows: Every third day the total amount of precipitation that has fallen since the beginning of the month is summed up and marked in the coordinate system. In this way a discontinuous summation curve is arrived at. For instance: it is seen that the rainfall in May 1943 was very slight, the precipitation being only c. 10 mm and falling exclusively in the period from the 6th to the 12th.

The whole period from August 1942 to November 1943 was relatively poor in rain. Only in August 1943 the rainfall was about double the amount of the normal precipitation of this month: but as the greater part of this fell in a couple of very heavy showers at the beginning of the month, it benefited neither the plants nor the ground water to the extent that might have been expected. Notably the early summer of 1943 was dry.

The ground water level undergoes considerable fluctuations on the Plain. The extreme points are represented by the maximum in the winter months and the spring and the minimum in midsummer and late summer. Table 2 gives information of the fluctuations of the ground water level in the period of investigation.

Table 2.

Date	Well in localities			Comments
	I	V	VII	
	cm	cm	cm	
18-10-42	— 98	— 53	— 46	
19-11-42	— 88	— 43	— 38	
12- 1-43	— 72	— 27	— 21	
31- 1-43	— 25	0	+ 7	Pl. V partly dry, partly covered with water
7- 3-43	— 71	— 28	— 21	
11- 4-43	— 79	— 36	— 30	
15- 5-43	— 91	— 50	— 43	
17- 6-43	ca. — 110	ca. — 70	— 63	Water level at any rate 20 cm lower than in May
18- 8-43	dried up	dried up	dried up	
7-11-43	„	„	„	

It will be seen that the period poor in precipitation has resulted in a considerable lowering of the ground water level.

The vegetation and the ground water.

As already mentioned, the sand has a capillarity of c. 25 cm. The network of roots nowhere descends lower than c. 20 cm. If, therefore, the plants are to have any chance of utilising the ground water, the level of the ground water must in no place be less than c. ½ m*). The height of the ground water is marked with horizontal lines in Fig. 11. The maximum was attained in January 1943, when Pl. VII, VI, and partly Pl. V were covered with water. But already in March the water surface in Pl. I had fallen to 70 cm below the surface of the soil. That is to say that from the very beginning of the growth period Pl. I and also Pl. II and III had to manage without the ground water. Pl. IV occupies an intermediate position. Not until about the beginning of June do Pl. V, VI, and VII become independent of the water supply from below and must get on exclusively by means of the precipitation. It should be pointed out, however, that the ground water measurements made

*) It must be mentioned that capillary movements in a soil like this (grain size 0.6-0.1 mm) take place with considerable speed (ATTERBERG 1903, BAVER 1940).

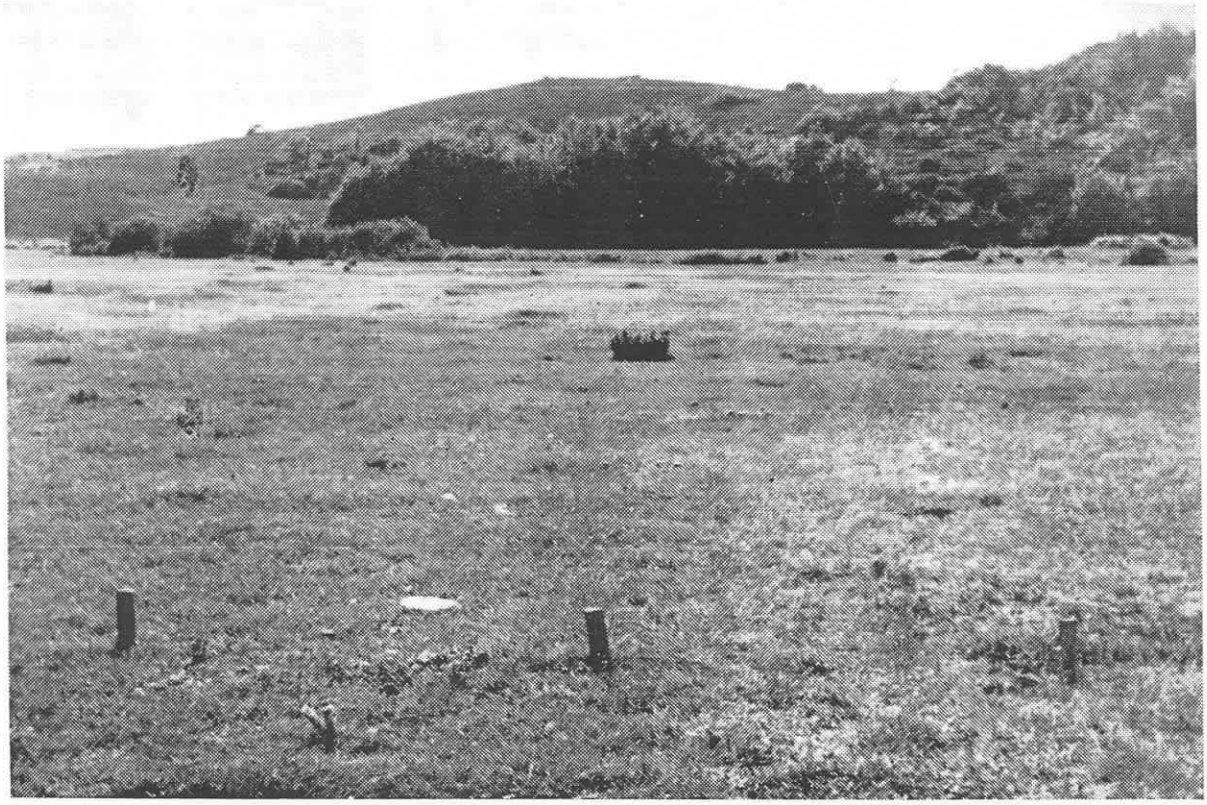

Fig. 14. A tract from the transition between the part of the plain dependent on and that independent of the groundwater: Pl. IV and Pl. V, August 1943. It is seen that the vegetation below Pl. IV is green and succulent, while above it is parched. — The cover of the well on Pl. V is seen. (Thamdrup phot.).

at the profile diggings in August 1942 render it probable that in summers with normal moisture the surface of the ground water in the low moist localities never sinks below 40-50 cm. It will be remembered that the species occurring here are precisely in great part characteristic of the supralittoral zone which is dependent on the ground water. Typical examples are: *Carex demissa, Carex panicea, Brunella vulgaris, (Juncus squarrosus),* and *Achillea ptarmica.* These species are only found on Pl. V or very scattered and sparsely on Pl. IV. — The character species in the dry part *(Gnaphalium arenarium, Hieracium pilosella,* and *Polytrichum piliferum)* are known precisely as being able to survive even a long period of drought. Fig. 14 was taken in August 1943 and shows Pl. IV and V. The difference between the green zone dependent on the ground water and the scorched zone independent of the ground water is distinctly seen.

DESCRIPTION OF THE HABITATS.

Description of the habitats: that is to say, description of the haunts of the animals. — The above-ground vegetation is characterised by the fact that the individual parts of the plants are separated from each other by interspaces of air. The transition from the above-ground vegetation to the upper

layer of the soil is often gradual; but in the latter the interspaces between the living parts of the plants (stems, roots, tubers and the like) are mainly filled with organic remains and mineral components. — According to this definition the hemiedaphon (KRAUSSE 1928 and GISIN 1943) or »Streufauna« (VOLZ 1934) has its habitat below the surface of the soil. — The present section contains a description of the conditions under which the hemiedaphic and euedaphic animals live. In this investigation no distinction has been made between the hemiedaphon and the atmobios, since the uppermost sample in a series contains both the relatively thin above-ground vegetation and the uppermost centimetre of the soil.*)

In the localites on the Plain the soil is in the main made up of 5 components: **sand** of a grain size of 0,6-0,1 mm, **living parts of plants,** formed and unformed **organic remains,** and finally **water** and **air,** the amount of which undergoes great seasonal variations in contrast with the three first-mentioned constituents.

The properties of the microcaverns depend on the mutual position and mixing of these components. The microcaverns are the haunts of the subterranean animals and their size, number, and character must be supposed to be of great importance to the animals. — A habitat which is bounded by quartz walls is very different from one whose walls are formed of roots and organic mud. — It must be emphatically maintained that a measurement of the pore volume of the layers can give no idea of the qualities of the microcaverns but only of the total space at the disposal of the animals. Two kinds of soil with the same deposition of the particles but with a different grain size have the same pore volume, but the size (pore width) and amount of the microcaverns is different (RAMANN 1911, pg. 297).

As it is not yet known which factors are of importance to the animals the description of the habitats has been made as detailed as possible.

The part of the soil examined was divided into 5 layers:

Layer 1: 0-1 cm including the vegetation
Layer 2: 1-2 cm
Layer 3: 2-3 cm
Layer 4: 3-4 cm
Layer 5: 4-5 cm

The qualitative investigation.

Description of the soil, especially the microcaverns, from direct observation. The procedure was as follows. Intact soil samples, $\frac{1}{1000}$ sq. m, 0-5 cm, from

*) The surface conditions are mentioned in the chapter entitled »Description of Localities«. We shall merely repeat that the free area of the surface is dependent on the density and growth form of the dominant plants.

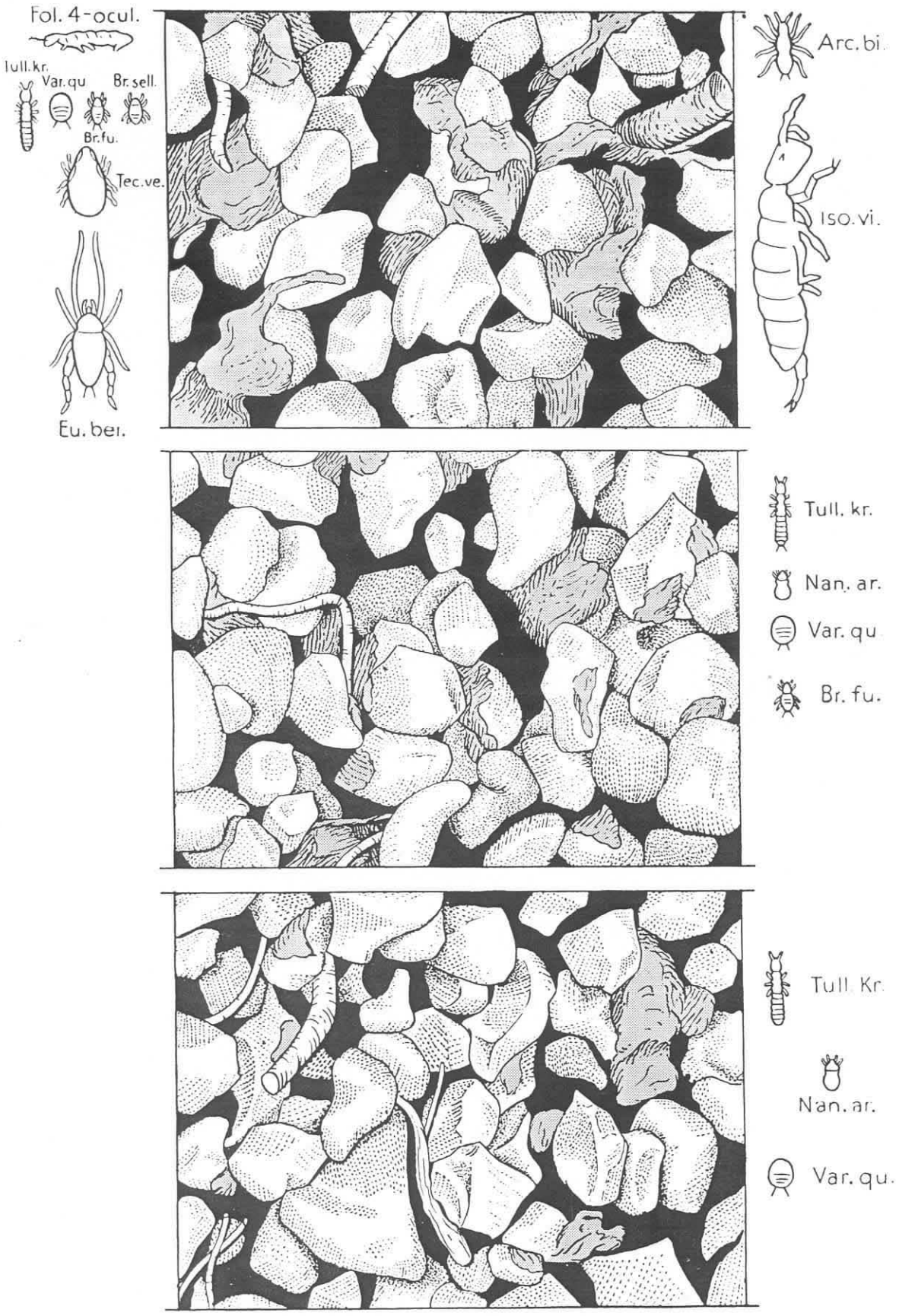

Fig. 15. Soil sections. Pl. I. See text pg. 171.

Pls. I, IV, and VII were laid on a piece of paper. Each sample was now with a sharp and thin knife cut into 4 transverse slices, so that 3 cut surfaces at depths of 1, $2^1/_2$, and $4^1/_2$ cm respectively were produced. The cut surfaces were examined under a binocular microscope, magnification × 24. A typical area was selected and drawn by means of an ABBE apparatus, linear magnification × 40, see Fig. 15-17. — In the margin the dominant or characteristic animal species in the layers in question were drawn with the same magnification. We shall revert to this later.

Further, in August 1942 an analysis was performed of the dredged organic material in the 5 layers on Pls. I, IV, and VII; a small soil sample, as much as covered the point of a knife, from each layer was fixed and shaken vigorously in 70 p.c. alcohol, and set aside for precipitation in a pointed glass made of a prolonged test tube. A pipette drop of the fine mud was laid on a slide, flame fixed, and mounted in glycerine-gelatine. The dredged material consisted partly of parts of roots and other formed substances with distinct cell structure, and partly of mud without any structure. In addition a number of fine mineral leaves were found.

Pl. I, 0-1 cm. Fig. 15, 1 cm depth. The layer contains few roots, which are unequally distributed. Parts of stems and rhizoids of *Polytrichum piliferum* are in several places matted with the sand while the lichens have no subterranean parts of significance. Transverse section: The sand closely packed. Roots of no significance for the microcaverns, which are numerous and large, the organic remains lying only as a thin layer on the outside of the sand-grains. Dredging showed many living stellate hyphae and moss rhizoids. Many formed organic remains surrounded by a net of hyphae.

1-2 cm: Few hyphae and comparatively more mud.

2-3 cm. Fig. 15, $2^1/_2$ cm depth.

The soil is homogeneous. Few thin roots. The sand is deposited closer than in 0-1 cm. Microcaverns large and numerous. Organic remains mostly in the »corners«; they consist chiefly of mud with fine hyphae and few formed components.

3-4 cm. Organic remains almost fine mud, more closely lumped together in the upper layers. Scattered fine hyphae.

4-5 cm. Fig. 15. $4^1/_2$ cm depth.

In every respect similar to the preceding layers.

$7^1/_2$ cm depth. Fine mud with delicate hyphae.

Pl. IV, 0-1 cm. Fig. 16. 1 cm depth. The organic elements constitute a considerable part of the total volume of the sample, and the sand grains lie lumped together in small groups, among which roots and organic remains

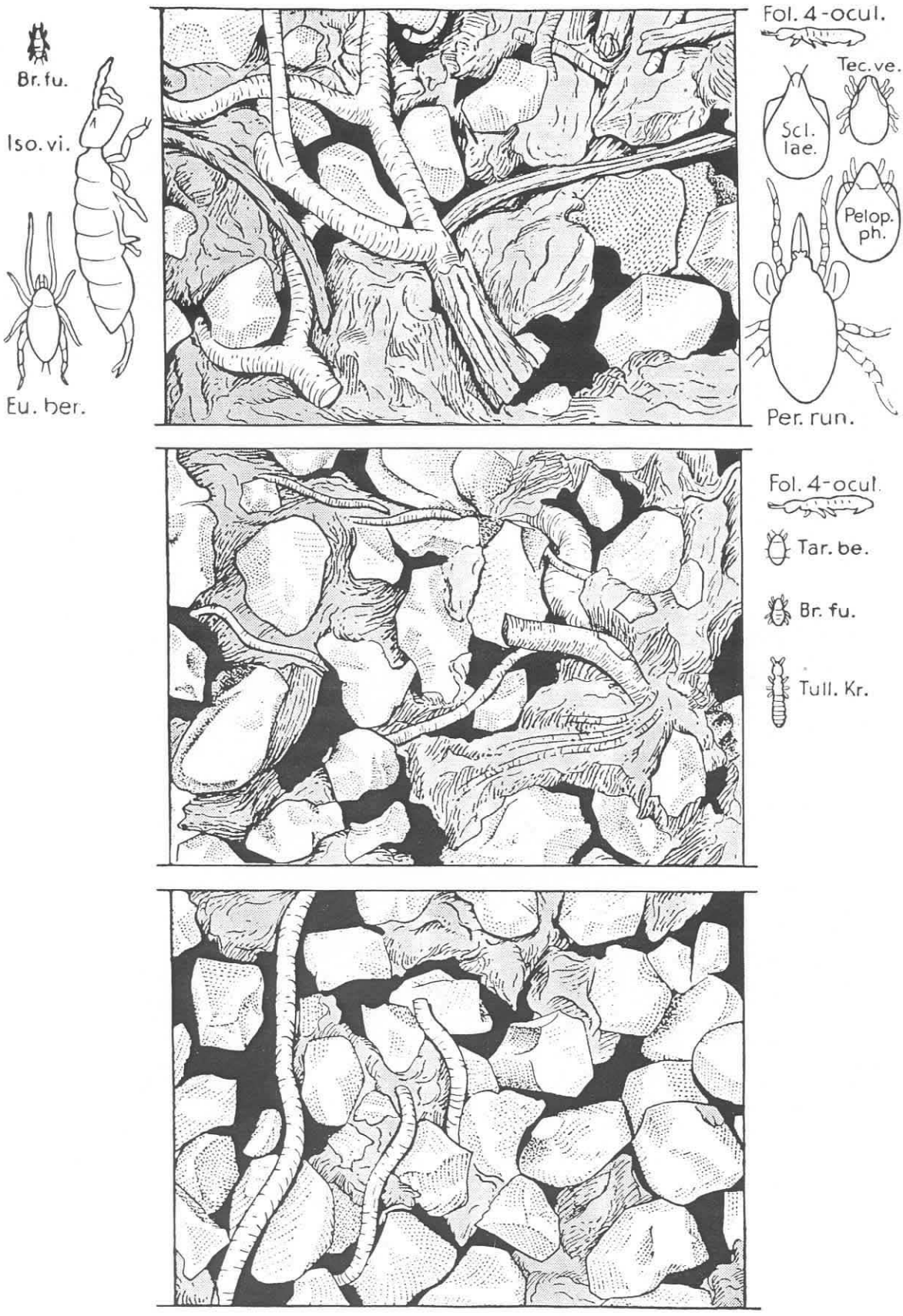

Fig. 16. Soil sections. Pl. IV. See text pg. 174.

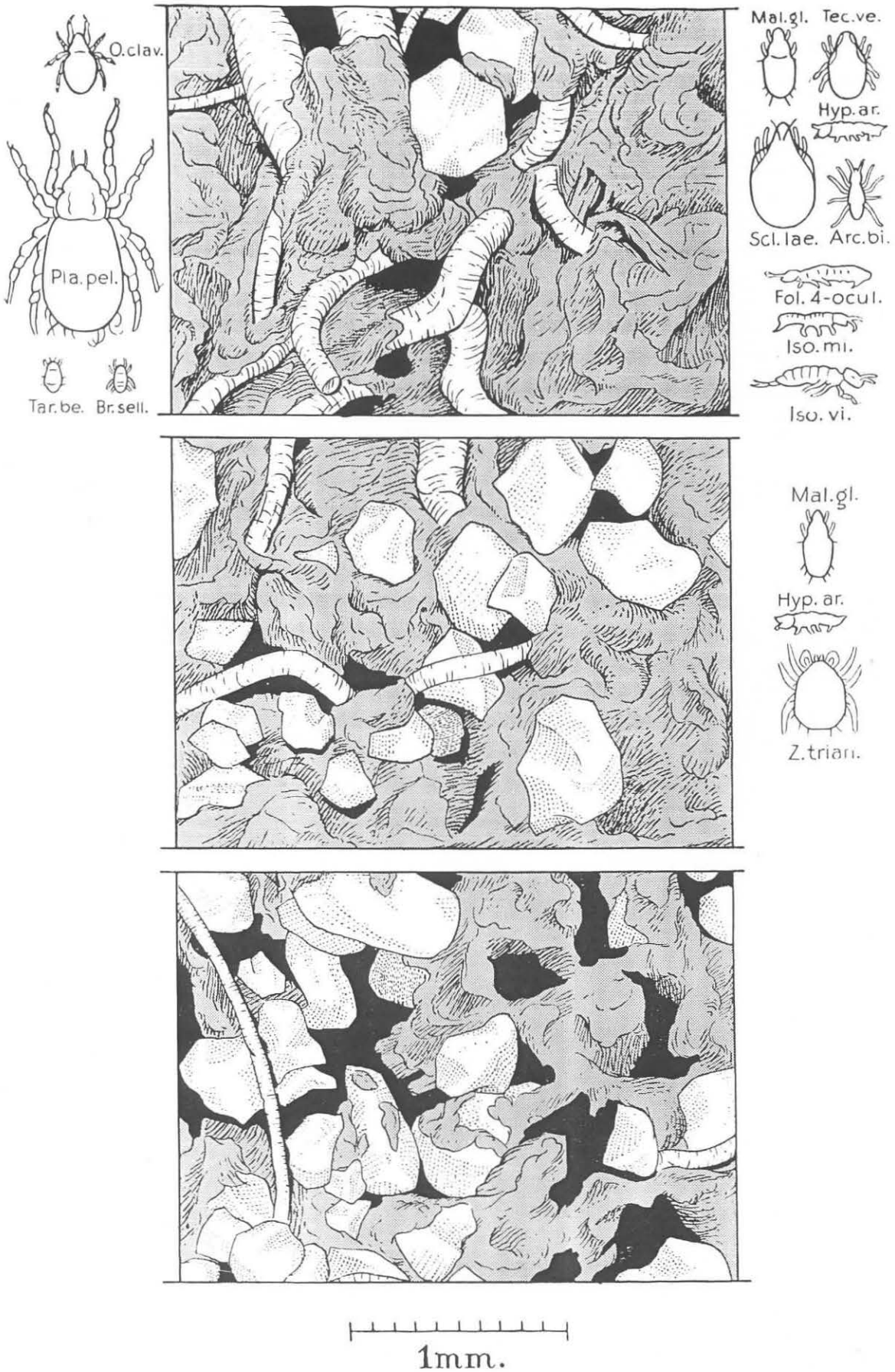

Fig. 17. Soil sections. Pl. VII. See text pg. 174.

fill up the spaces. The base of the grass stems lies partly in this *(Agrostis)* and partly in the layer 1-2 cm. The microcaverns are comparatively few and small, the sand-grains being covered with mud and formed remains. On the other hand, rotting stems and new shoots constantly make channels of communication between the surface and the deeper parts of the layers. Dredging showed many formed elements surrounded by a net of hyphae; but otherwise the amount of hyphae and rhizoids is small compared with Pl. I, 1-2 cm. The root net of the *Sieglingia* plants begins in this layer. There are still a good many formed remains in the dredged sample.

2-3 cm. Fig. 16, $2^1/_2$ cm depth. The sand-grains here lie considerably closer: but the root net is still vigorous. The microcaverns are frequently filled with mud, the quantity of which increases as compared with the formed remains.

3-4 cm. Organic substances: Only scattered remains of roots, the rest mud.

4-5 cm. Fig. 16, $4^1/_2$ cm depth.

The sand lies close, the organic remains fill up part of the microcaverns, and the number of »traversable« microcaverns does not seem to be much increased.

Pl. VII, 0-1 cm. Fig. 17, 1 cm depth. The sand is quite insignificant, the root net is extremely vigorous, and the greater part of the roots belongs to *Hieracium auricula*. Between large roots and stems there are sometimes wide channels, while the intermediate mass is dense and sticky. Dredging showed remains consisting exclusively of loose flocculent mud with few hyphae.

1-2 cm. This is the layer containing *Sieglingia*'s stems and the root net is very dense. The mud is finer and the amount of hyphae and rhizoids less than in the layer 0-1 cm.

2-3 cm. Fig. 17, $2^1/_2$ cm depth.

The sand is more conspicuous, there are no stems, the roots are thinner, but the root net is dense. The microcaverns are all filled with still finer mud. The soil is sticky and heavy.

3-4 cm. Similar to the preceding layer.

4-5 cm. Fig. 17, $4^1/_2$ cm depth.

The sand again dominates the picture and is the chief constituent. The soil is not sticky, the roots are sparse, and the microcaverns only partly filled up; the mud is fine and slightly granular.

Comparison. While the sand is the chief component in the lower layers of all the localities, the living and dead organic constituents dominate the picture in the upper layers in Pls. IV and Pl. VII. Simultaneously with an increase in the amount of organic matter there is a decrease in the number and size of the microcaverns, and the walls of these gradually come to be formed exclusively of roots and mud. In the layer 2-3 cm on Pl. VII almost

all the microcaverns are filled with mud. On Pl. IV this is only partly the case. The large channels in the layers 0-1 and 1-2 cm on Pl. IV and VII have already been mentioned in the preceding part.

The dredgeable organic remains on Pl. I contain many remnants of roots and hyphae, on Pl. IV the remains of roots dominate, while fine flocculent mud is almost solely prevalent on Pl. VII. Thus there is also a difference in the structure of the organic matter in the various localities.

In all the localities there occured *Difflugia* shells. They were particularly numerous in the layer 1-3 cm on Pl. I and Pl. IV. A preliminary study seems to show that the dominant species differed in the high and the low locality.

Unicellular algae were found, but were not common. Thus pennate diatoms (*Navicula* and others) occurred, most frequently in the upper layers and decreasing downwards; but in several places at a depth of 3-4 cm. At this time, however, the number of the algae was so small that they did not seem to be of any great significance for the nourishment of the microfauna.

Quantitative analysis.

The result will be seen from Table 3 (behind).

1. The dry weight of the BERLESE samples is the average of 10 series from each locality. As the size of each sample is about 10 c. c. the dry weight indicates the volume weight of the layer in question.

2. The ignition loss of the BERLESE samples calculated partly in per cent of the dry matter, partly in per cent of the mineral weight. The values from Pls. I, IV and VII are the average of 5 series of analyses.

On Pl. II, III and V only 1 series was analysed.

Usually the ignition loss of a soil sample is expressed in per cent of the dry matter. The value will in that case show how great a proportion the organic matter constitutes of the whole soil sample, with the sand and the organic matter taken together, but it does not show directly the proportional amounts of the two components. Ignition loss p. c. $= \frac{\text{ignition loss} \times 100}{\text{sand} + \text{ignition loss}}$.

As will be seen, in this case the ignition loss enters both into the numerator and the denominator. When the content of organic matter in a series of soil samples varies greatly, the ignition loss percentage, by this method of calculation, will give quite erroneous ideas of the proportional amounts of the components.

Example: 2 samples a and b.

a — ignition loss in p. c. of dry weight — 80 p. c.

b — — — - — - - — — 50 p. c.

The difference between a and b does not seem very large, but from the proportion in which the components are mixed it is seen that the case is quite different.

Dry weight Ignition loss Root content and Mean water content	Pl. I								Pl. II				Pl. III				Pl. IV					
	Dry weight (mean) Grammes	Ignition loss (mean)		Root content				Water content p.c. of dry weight	Dry weigth (mean) Grammes	Ignition loss		Water content p.c. of dry weight	Dry weight (mean) Grammes	Ignition loss		Water content p.c. of dry weight	Dry weight (mean) Grammes	Ignition loss (mean)		Root content		
				Mg per sample		In p.c. of														Mg per sample		In p.c
		P.c. of dry weigth	P.c. of miner. weight	I Series	II Series	dry weight	mineral weight			P.c. of dry weight	P.c. of miner. weight			P.c. of dry weight	P.c. of miner. weight			P.c. of dry weight	P.c. of miner. weight	I Series	II Series	dry weight
0-1 cm	**8,1**	16,0	*19*	318	297	3,8	*4,0*	**29,2**	**7,9**	11,8	*13,4*	**31,9**	**8,0**	19,7	*24,5*	**38,5**	**5,9**	31,8	*46,6*	426	899	11,0
1-2 cm	**12,8**	2,9	*3*	87	68	0,6	*0,6*	**11,6**	**12,1**	4,0	*4,1*	**15,8**	**12,0**	7,8	*8,5*	**21,1**	**8,4**	13,8	*16,0*	215	147	2,2
2-3 cm	**15,0**	2,8	*2,9*	83	26	0,4	*0,4*	**8,6**	**14,8**	2,7	*2,8*	**10,1**	**13,6**	4,8	*5,0*	**15,9**	**12,1**	7,9	*8,6*	122	101	0,9
3-4 cm	**14,5**	2,1	*2,1*	52	28	0,3	*0,3*	**8,6**	**13,9**	2,6	*2,7*	**8,2**	**12,7**	4,7	*4,9*	**13,5**	**12,7**	6,7	*7,2*	98	63	0,6
4-5 cm	**16,5**	1,9	*1,9*	34	22	0,2	*0,2*	**7,8**	**13,9**	2,6	*2,7*	**8,9**	**13,8**	4,2	*4,4*	**13,3**	**14,1**	6,2	*6,6*	86	49	0,5
5-10 cm				118	81			**6,8**				**10,1**				**14,3**				169		

Table 3.

Pl. III				Pl. IV								Pl. V				Pl. VII							
Dry weight (mean) Grammes	Ignition loss		Water content p.c. of dry weight	Dry weight (mean) Grammes	Ignition loss (mean)		Root content				Water content p.c. of dry weight	Dry weight (mean) Grammes	Ignition loss		Water content p.c. of dry weight	Dry weigth (mean) Grammes	Ignition loss (mean)		Root content				Water content p.c. of dry weight
							Mg per sample		In p.c. of										Mg per sample		In p.c. of		
	P.c. of dry weight	P.c. of miner. weight			P.c. of dry weight	P.c. of miner. weight	I Series	II Series	dry weight	mineral weight			P.c. of dry weight	P.c. of miner. weight			P.c. of dry weight	P.c. of miner. weight	I Series	II Series	Dry weight	Mineral weigth	
8,0	19,7	*24,5*	**38,5**	**5,9**	31,8	*46,6*	426	899	11,0	*14,1*	**83,9**	**5,1**	27,0	37,0	**124,3**	**4,5**	37,8	*60,8*	548	1022	17,4	*28,2*	**152,7**
12,0	7,8	*8,5*	**21,1**	**8,4**	13,8	*16,0*	215	147	2,2	*2,5*	**41,0**	**7,7**	14,8	17,3	**69,4**	**6,9**	19,1	*23,6*	208	741	6,9	*8,6*	**84,1**
13,6	4,8	*5,0*	**15,9**	**12,1**	7,9	*8,6*	122	101	0,9	*1,0*	**28,3**	**11,2**	11,6	13,1	**37,9**	**8,9**	14,3	*16,7*	106	175	1,6	*1,8*	**56,3**
12,7	4,7	*4,9*	**13,5**	**12,7**	6,7	7,2	98	63	0,6	*0,7*	**22,2**	**11,3**	8,3	9,1	**30,6**	**11,0**	11,2	*12,6*	104	110	0,9	*1,1*	**39,3**
13,8	4,2	*4,4*	**13,3**	**14,1**	6,2	*6,6*	86	49	0,5	*0,5*	**19,1**	**12,3**	7,0	7,5	**26,0**	**13,2**	10,2	*11,4*	85	101	0,7	*0,6*	**32,4**
			14,3				169				**22,2**				**32,3**				241	224			**38,2**

Table 3.

a = ignition loss in p. c. of mineral weight = 400 p. c.

b = " " " " " = 100 p. c.

The physico-chemical properties of the soil must depend amongst other things on the proportion in which the components that form it are mixed and it will therefore be reasonable also to calculate the ignition loss percentage from the mineral weight.

3. The root content is calculated in per cent partly of the dry weight, partly of the mineral weight.

The root content was only determined on Pl. I, IV, and VII, and only two series from each locality have been analysed. Thus there is a margin for even wide variations; nevertheless the values should give some idea of the share of roots in the total amount of organic matter. It should be noted that the root content in samples 0-1 cm comprises some green parts of plants too. The values from this layer, therefore, show great fluctuations.

4. The average water content of the Berlese samples in per cent of the dry weight. 10 series from each locality taken at intervals during the investigation period.

THAMDRUP (1939, pg. 13) and AGRELL (1941, pg. 96) calculate the water percentage from the fresh weight. In this way the variable quantity enters into the numerator as well as the denominator. This method is usually adopted in the technique; but since it is precisely the relation between water and dry matter which is of significance for the understanding of the whole water problem, the water percentage calculated from the dry weight is much to be preferred in an investigation of this kind (cp. RAMANN 1911, pg. 336)

5. The variations in the water content have been investigated and are represented graphically.

1. The volume weight. Fig. 18 shows the correlation between the volume weights of the individual layers and the position on the sampling line. For all the layers the volume weight decreases towards Pl. VII. The deepest layers exhibit the highest values, and the two upper layers differ distinctly from the three lower ones, the volume weights of which decrease gradually towards Pl. VII. On the other hand, as far as the two upper layers are concerned, it drops suddenly between Pl. III and Pl. IV, that is to say, where the dense grass vegetation begins. The absolute values will appear from the table and the figure.

2. Ignition loss. Fig. 19. shows the correlation between the ignition loss of the various layers (in per cent of the mineral weight) and their position on the sampling line. The values denoting the average of several analyses are enclosed in a circle. — As will be seen, in all the layers the ignition loss rises towards Pl. VII; altogether the ignition loss increases when the volume weight

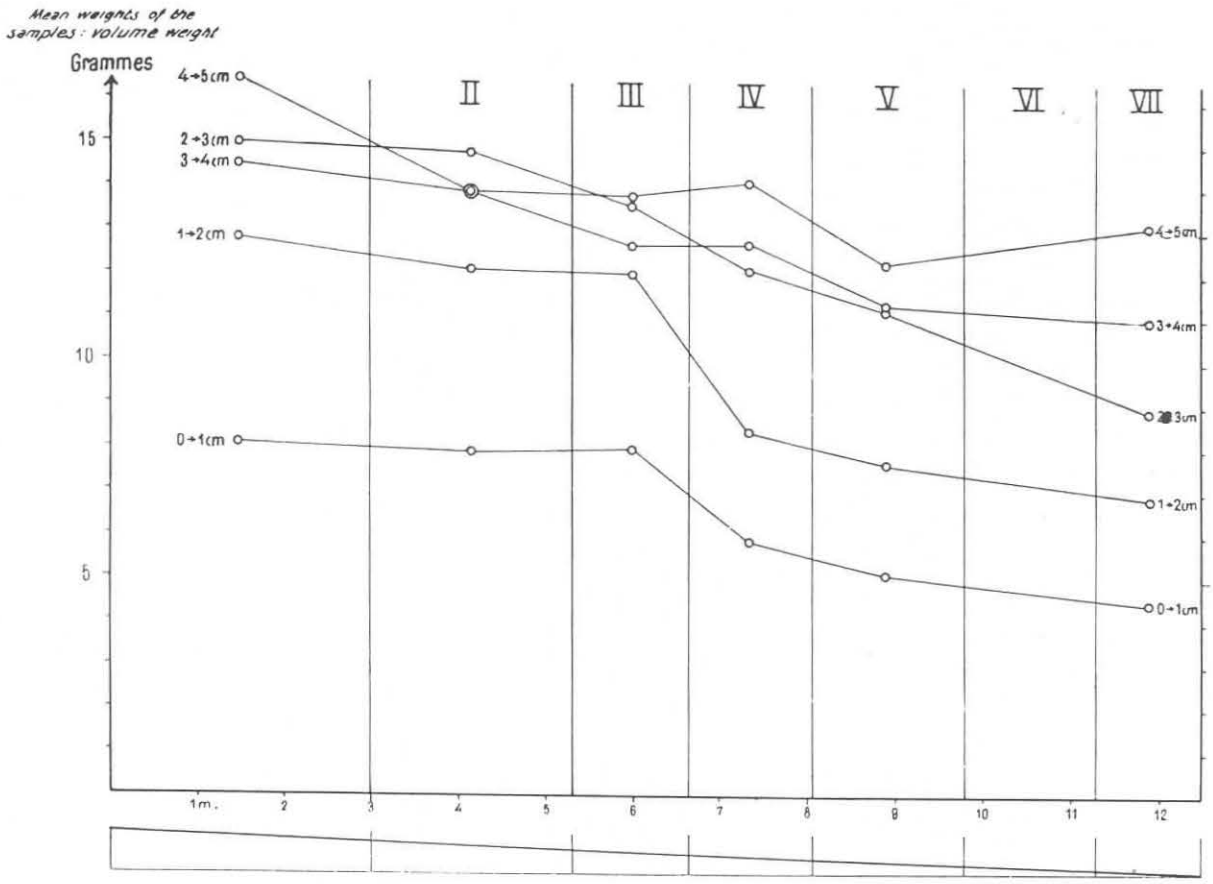

Fig. 18. Mean weights of samples: volume weights. 1 sample = 10 ccm.

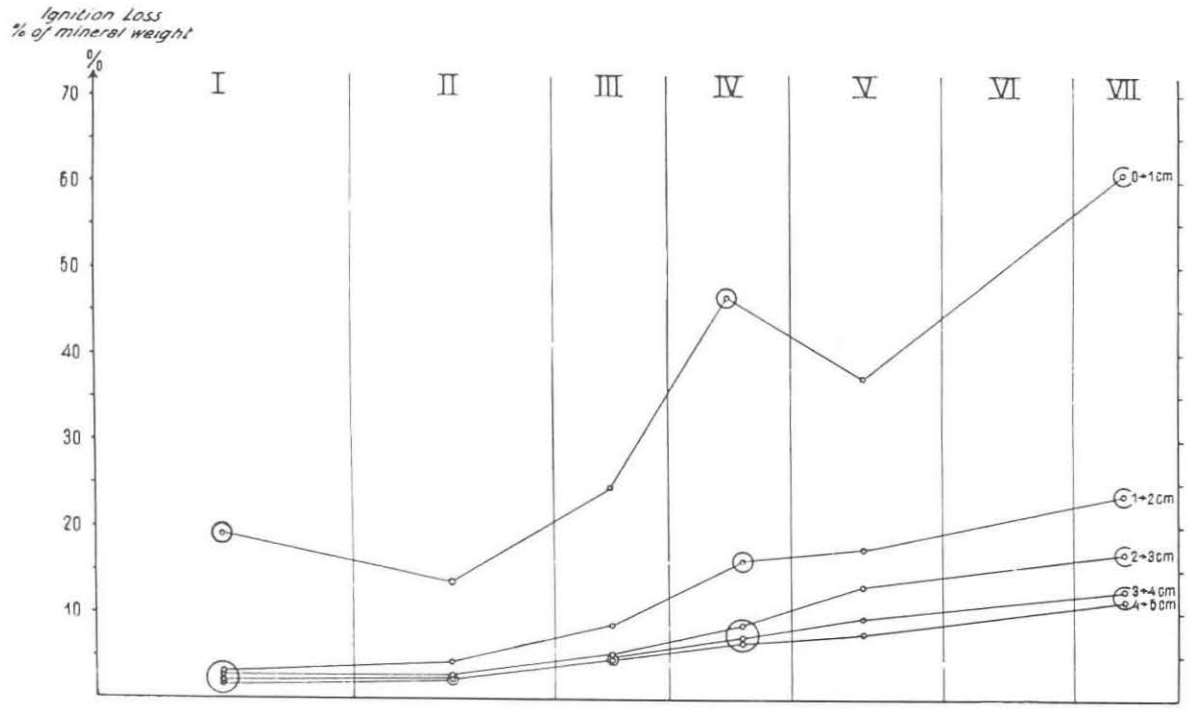

Fig. 19. Ignition loss in per cent of the mineral weight.

decreases. That is to say, towards Pl. VII the sand grains are pressed apart and the interstices are filled with organic matter. As might be expected, corresponding to the sudden decrease in the volume weight between Pl. III and Pl. IV in the layers 0—2 cm, there is a rise in the ignition loss, caused by the dense grass vegetation and its many roots.

Fig. 20 shows ignition loss and root content (dried up roots), in per cent of the mineral weight in the various layers in the 6 localities. The root content is hatched. The unhatched part denotes the amount of dead organic matter = the humus content.

RAMANN (1911, pg. 170) has divided sandy soils according to their humus content as follows: (translated from the German)

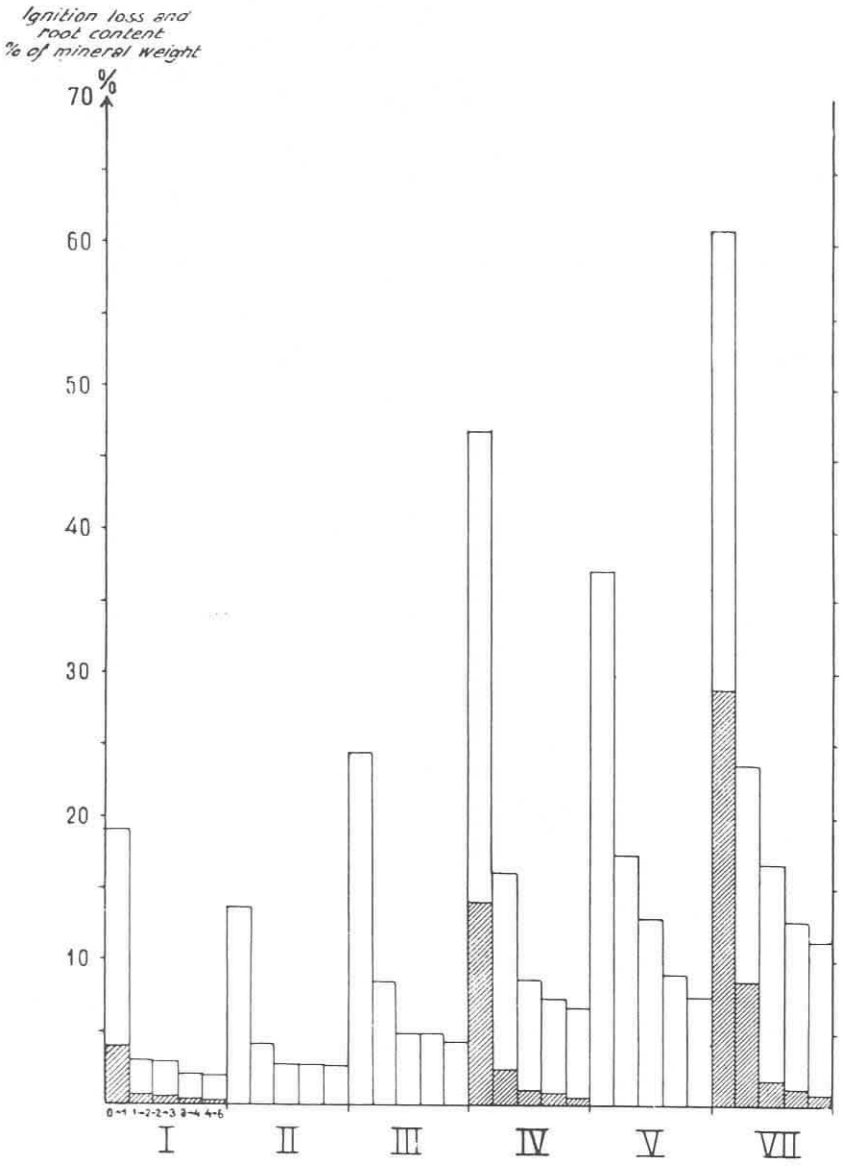

Fig. 20. Ignition loss and root content (hatched) in per cent of the mineral weight.

Sandy soil poor in humus	up to 1 p. c. of humus
— — containing some humus	1-2 p. c. - —
— — humous	2-4 p. c. - —
— — rich in humus	4-8 p. c. - —
— — over-rich in humus	> 8 p. c. - —

Since he measured the humus content in somewhat deeper layers the root content has but little influence on his results. — If the humus content of the different layers is compared, it will be seen that the lower strata in the dry localities correspond to sandy soils containing humus or humous sandy soils, while in the moist localities they are rich or over-rich in humus. If in the individual localities we pass from the surface downward, we pass through layers of widely different humus content; but the general rule is that the upper layers are over-rich in humus and have a humus percentage corresponding to that of rich mould or exceeding it. But the mould is characteristic by having a loose structure, so one cannot compare the upper layers of the Plain with rich mould and the lower layers with light sandy mould, as one might be tempted to do owing to the humus percentage.

3. The root content. The ignition loss comprises both living and dead organic matter. However, the living and dead organic components are of different significance for the structure and other properties of the soil. — Shoots, stems, and roots grow, cease growing, die, and are replaced by new ones; thus they are capable of actively breaking through the soil and may thus change the composition and structure of this soil. The living parts of plants might suitably be called the active form component in contrast with the other passive components. They form an ordered, continuous system which might be called the subterranean vegetation net. If this net is vigorously developed, it encloses all the other components and keeps them together. The root turf of the lower localities is an example of this. In the high localities the net is slightly developed and only in the uppermost layer is it of such a magnitude that it can keep the sand together. The net here consists not of roots, but of moss stems, moss rhizoids, and stellate hyphae. — The water content in the subterranean vegetation net is mostly constant.

Commonly the main part of the subterranean vegetation net consists of roots and is here usually called the root net. — In the dry condition the root content can be measured in units of weight and be expressed in per cent of the dry weight or the mineral weight. As I have not been able to find quantitative investigations on the subterranean vegetation net in the literature, I cannot compare my values with the results of others.

As already mentioned, Fig. 20 shows the magnitude of the root content, ex-

pressed in per cent of the mineral weight on Pl. I, IV and VII (the hatched part). — The corresponding weights of the living and the dead organic matter can be directly read. — It will be seen that while the ignition loss increases towards Pl. VII, the root content rises, as was to be expected; but while the ratio $\frac{\text{root content}}{\text{humus content}}$ in the layer 1-2 cm on Pl. I is approximately as 1:7, the corresponding ratio on Pl. IV is approximately as 1:6 and on Pl. VII more than 1:3. — The living matter increases in amount as compared with the dead matter towards the low part of the sampling line. — The differences between the root content in the deeper layers in the various localities do not seem to be very large; but when you have the samples before you, they are seen to differ widely in appearance. It may be mentioned that the layer 4-5 cm on Pl. VII has the same root content as the layer 1-2 cm on Pl. I.

In the dried state the underground vegetation net in the layer 1-2 cm constitutes at most 8-9 p. c. of the mineral weight (Pl. VII). (The values from the layer 0-1 cm are somewhat higher, and a large part of the »root content« is derived from the green parts of plants). — The specific gravity of fresh roots is about 1, that of sand 2,7, and from this it is seen that the volume of the roots in a layer of soil with a root percentage of 8 constitutes about 110 p. c. of the volume of the sand, that is to say, a very considerable part.[1])

4. The water content. The importance of water for the flora and fauna is emphasised again and again in ecological and sociological literature. Almost in every publication the terms xerophilous, mesophilous and hygrophilous are met with; but the significance of water for the subterranean organisms is so little known that the use of these terms and the distinction drawn between them is almost always based on the author's judgment. A quotation from AGRELL's work on the ecology of the *Collembola* (1941, p. 106) illustrates quite well the stage of our present knowledge: »So bin ich durch diese meine Untersuchungen über den Feuchtigkeitsbedarf der Collembolen zu der bestimmten Überzeugung gelangt, dass die Feuchtigkeit, der Wassergehalt des Bodensubstrats, derjenige Umweltfaktor ist, der vor allen andern die Verteilung der Collembolen in der Natur bestimmt«. — AGRELL is one of the few authors who have attempted to determine the moisture requirements, moisture preference and resistance to desiccation of the various species; but he did not always find agreement between the experimental results and the results he had arrived at from his collections in the field. — MARIE HAMMER (1937, pg. 44) ascertained that the number of *Collembola* was much higher in the dry than in the moist localities. Thus *Folsomia quadrioculata*, which according to AGRELL

[1]) Water constitutes about 80 p. c. of the fresh weight in living plants. When dried root-substance constitutes 8 p. c. of the mineral weight, dried substance + root-water will thus constitute 40 p. c.

shows little resistance to desiccation, is entirely dominant on the dry lichen heaths at Angmagssalik, Greenland. — AGRELL has given the water content of the individual samples in per cent of the fresh weight. With this inappropriate mode of calculation the actual differences between the water contents of the samples is partly smoothed out, so that the results are less distinct. — HANDSCHIN (1926, pg. 48), GISIN (1943) and others point out that the distribution of the collembolan communities in nature must be studied in close connection with the varying water content of the soil. — GISIN even divides the hemiedaphic collembolan fauna into a xerophilous, a mesophilous and a hygrophilous group. These groups represent different life forms. In the individual groups the synusiae are arranged according to their increasing moisture requirements. GISIN has not investigated the water content of the localities but has formed an estimate of it from the vegetation. Since, as already mentioned, he has found a close connection between the plant communities and the collembolan communities, there can be no doubt that the water content is of considerable significance for the composition and distribution of the collembolan communities. FRENZEL (1936, pg. 108) and HAMMER (1934, 1937 and 1944) have shown that this also applies to the rest of the microfauna.

Our object in the present section is to give an account of the water conditions in the individual localities and to show that ecological conclusions as to the dependence of the soil animals on the water content cannot simply be drawn from the average water percentages of the samples.

The occurrence of the water. As already mentioned, the water is the variable component of the soil. — Heavy showers will cause the pores of the low-lying part of the Plain to be completely filled with water, while in the high-lying localities it will speedily sink into the lower layers. A large humus content, and particularly a high content of colloid humus substances, as we find it on Pl. VII, increases water retention.

In the investigation period 1942-43 the low-lying stations were under water at the close of January; but already at the beginning of March the ground water had sunk 20-30 cm below the surface. After that time the soil has not been saturated with water for long periods. — In years with a normal amount of precipitation large parts of the Plain are, however, flooded during the whole of the cold season.

The water in the soil has been separated into several different fractions by different authors. The boundaries of these fractions are not very sharp and thus it is impossible to separate them. They are not in their prime definite form dealt with in the new theories based upon the energy relationships of the soil water. The pF-value represents an expression of the capillary potential. pF is defined as the logarithm of the height in centimeters of a liquid

(here water) column that is necessary to produce a suction which corresponds to the capillary potential value. Ex. pF = 2; the corresponding capillary potential represensts a suction power able to raise a water surface 100 cm. (see BAVER 1940, p. 193-245).

If the water content is determined in the ordinary way, part of the loss will, however, be derived from water which is bound to the living parts of the plants, more especially the roots, i. e. the root water referred to by ZUNKER (1930) as »osmotic water«, a bad name on account of the theory of capillary potential. In the soil samples taken by geologists, agriculturists, and botanists the root water will be without any great significance; but in the present investigation it plays a great role in the upper layers, as will be shown presently.

The water in the soil can thus be divided into two groups, the root water, which is bound to the living parts of plants and which is not usually of any importance for the moisture conditions of the soil, and the free water[1]), which is found in, on, and between the dead particles of the soil, and the amount of which varies with the ground water level, precipitation, draining, and evaporation.

Instead of using the conception capillary potential it is often practical to use other expressions of the same phenomenon, e.g. tensional force, measured in atmospheres, or to use the relative humidity of the air in the soil pores, R. H. — A single correlation exists between capillary potential, pF-value, tensional force and relative humidity.

When the soil contains plenty of water, its capillary potential is small and so is the tensional force, and the air in the pores is practically saturated with water vapour. If, however, the water content of the soil decreases the tensional force will rise considerably when the water percentage has attained a certain critical value, and the relative humidity in the pores of the soil falls (THAMDRUP 1939, pg. 71). — The size of the critical value depends on the nature of the soil, or more precisely on the grain size and the content of organic matter, and it is a well known fact that with a small grain size and a large content of humus the critical value is attained at a relatively high water content (cp. KEEN 1931, BOYSEN JENSEN 1938, and others).

Mr. KØIE has made several determinations of the tensional force and the water content at 5-8 cm depth in various localities, and he has kindly let me have some of his results, which have been summarised in table 4. The soil samples examined derive partly from the Plain and partly from Rogeshøj (see later).

[1]) BOUYOUCOS (Soil Sci., 11. 1921) introduced the term »free water« in quite another sense, i. e. water which does not move under force of gravity and which freezes at — 1,5° C. BOUYOUCOS's classification is now out of use.

M. Køie: tensional force. Measurements from soil at 5-8 cm depth	Gnaphalium locality at the sampling line			Sieglingia locality at the sampling line			Calluna locality at the sampling line			Calluna locality from the plain			Raw Humus from Rogeshøj		
Volume weigt	140,7			122,3			125,0			130,2			37,0		
Pore volume	45,7			52,0			45,0			40,2			80,2		
Spec. gravity	2,60			2,55			2,30			2,10			1,87		
Humus %	2,8-3,0 %						8,4-9,1 %			7,6-8,2 %			75,8-81,1 %		
p. H.	4,7			5,7			4,1			4,3			3,7		
Particles < 0,002 mm	1,0 %						0,3 %						4,9 %		
Date	Water content Weight %	Tensional force in Atm.	Relative Humidity of Air	Water content	Tensional force	R. H.	Water content	Tensional force	R. H.	Water content	Tensional force	R. H.	Water content	Tensional force	R. H.
27/6 - 1943	3,4	< 1	100							12,9	< 1		84,5	2,5	99,7
1-2/7 - 1943	1,3	52	99,5				8,5	1,9	99,8	6,0	5,3	99,5	62,2	7,6	99,5
3-4/7 - 1943	1,5	57	99,5				7,6	5,9	99,5	6,8	5,3	99,5			
21/7 - 1943	3,5														
28-29/7 - 1943	1,2														
1-2/8 - 1943	0,9	ca. 100	90-95	27,8	< 1	100									
	0,9	> 100	< 90												

Table 4

In the period of drought at the close of July and the beginning of August 1943 some measurements (Table 5) were made of the water content and rela-

	Water content, relative humidity, and temperature at 1—3 cm depth		
	Water content $^{28}/_{7}$-43	Relative humidity $^{1}/_{8}$-43	Temperature at 5—6 p. m. $^{1}/_{8}$-43
Pl. I	1,0 %	65—75 %	38—34°
Pl. II	1,5 %	69—75 %	34—35°
Pl. III	2,5 %	69—68 %	35—35,6°
Pl. IV	6,2—25 %	68—100 %	35,6—31°
Pl. V	25 %	96—100 %	31—24,6°
Pl. VI	27 %	96—100 %	24,6—24,8°
Pl. VII	38 %	96—100 %	24,8—24,7°

Table 5

tive humidity of the layers 1-3 cm in all the localities of the Plain (I, II, etc.). At the same time the temperature was measured. The humidity measurements were made with a hair hygrometer (cp. THAMDRUP 1939, pg. 14-16). This apparatus cannot measure values of more than 96 p. c. R. H. If the deflection is greater, the result can only be given as 96-100 p. c.

The grain size is nearly the same in all localities of the Plain, and it can be taken for granted that the content of organic matter determines the size of the critical value; the water percentage in the samples, very poor in humus, from the *Gnaphalium* zone must decrease to 1.5 p. c. before the relative humidity in the pores drops below 99.5 p. c. The critical value lies between 3 and 1.5 p. c.

In the *Calluna* localities which correspond nearly to Pl. IV or V the critical value of the water percentage is 6-8; but in the heather raw humus on Rogeshøj the tensional force begins to increase already at a water percentage of about 80; when the water percentage is about 55, the relative humidity in the pores is nevertheless as high as 98-99 p. c.

The water content and the organic matter. The correlation between the average water content of the individual layers and the position on the sampling line is seen in Fig. 21. — If we compare this figure with Fig. 19, which shows the ignition loss of the layers, it is plainly apparent that the two curve systems take a parallel course. The water percentage in the lower layers, the ignition loss percentage of which increases gradually towards Pl. VII, likewise rises; and corresponding to the sudden rise in ignition loss in the two upper layers between Pl. III and IV, we find a rise in the water percen-

tage. Further we see that the average water content in all the localities affords a guarantee that the air in the pores of the soil is saturated with water vapour, the four lowermost layers on Pl. I having an average water percentage considerably above the critical value.

To throw further light on the relation between water percentage and igni-

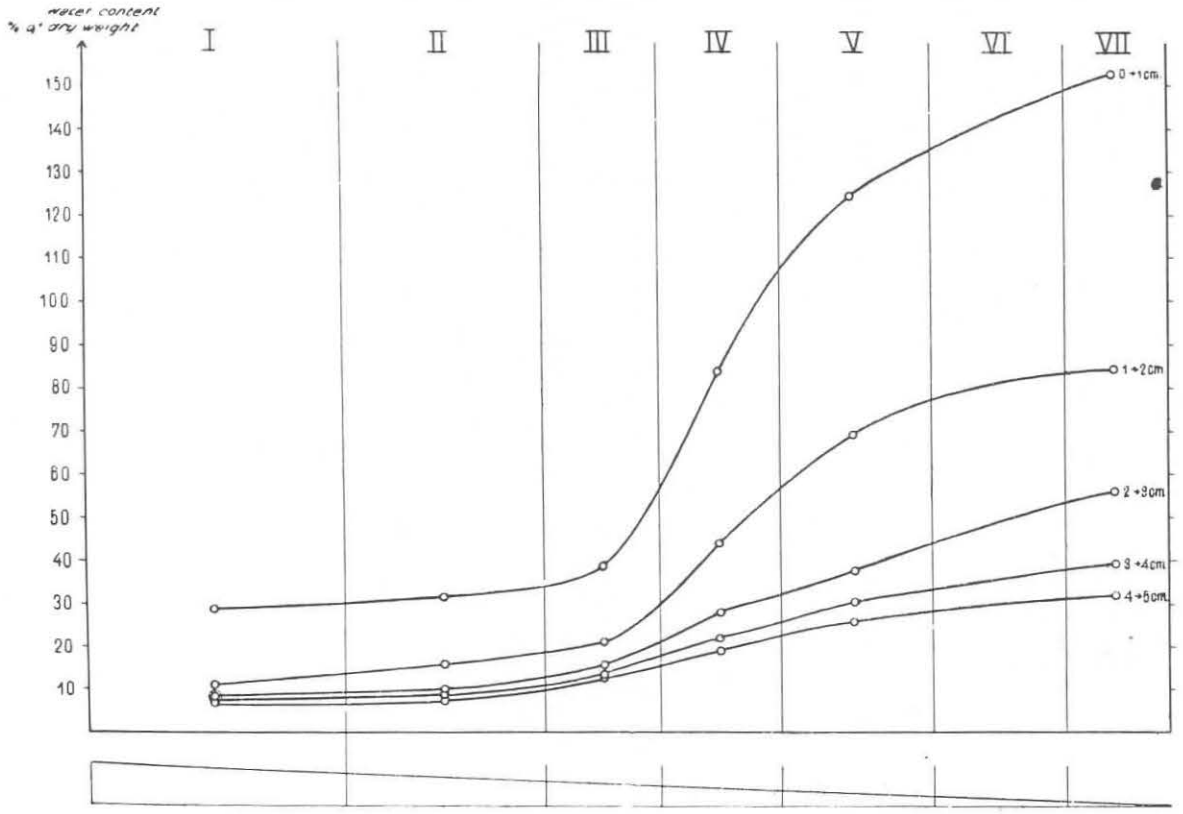

Fig. 21. Average water content in per cent of the dry weigt.

tion loss I have calculated the ratio, R, between the mean root water percentage and the mean free water percentage, and further the ratio, F, between the mean free water percentage and the humus percentage. R and F are given in fractions. The root water percentage has been found from the root percentage by multiplying by 4, on the assumption that the water constitutes about 80 p. c. of the living parts of plants (BOYSEN-JENSEN, 1938).

Free water p. c. = water p. c. — root water p. c.

Humus p. c. = ignition loss p. c. — root p. c.

All percentages were calculated from the dry weight of the samples and are therefore directly comparable. The basis values are seen in Table 3.

$$R = \frac{\text{root water}}{\text{free water}} = \frac{\text{root water p. c.}}{\text{free water p. c.}};$$

$$F = \frac{\text{free water}}{\text{humus}} = \frac{\text{free water p. c.}}{\text{humus p. c.}}$$

The result may be seen in the table 6.

It will be seen that in the uppermost layer R = 1. Thus the amounts of root water and free water are about equal. In other words, the root water con-

	Pl. I			Pl. IV			Pl. VII		
	Root water % / Free water % = R	Root water % mean water content	Free water % / Humus % = F	R	Root water % mean water content	F	R	Root water % mean water content	F
0-1 cm	1	1/2	1.2	1	1/2	2	1	1/2	2.7
1-2 cm	1/3	1/4	4	1/3	1/4	3	1	1/2	4.5
2-3 cm	1/6	1/7	3	1/3	1/7	3.5	1/7	1/8	4
3-4 cm	1/5	1/6	4	1/8	1/7	3	1/9	1/10	3.5
4-5 cm	1/8	1/9	4	1/8	1/9	3	1/10	1/11	3

Table 6

stitutes half of the water loss found in an ordinary desiccation analysis. In the next layer the root water constitutes 1/3 of the total amount of water. Pl. VII, however, forms an exception, no doubt on account of the large content of *Sieglingia* stems. The share of the root water in the total amount of water decreases rapidly with the depth as was to be expected.

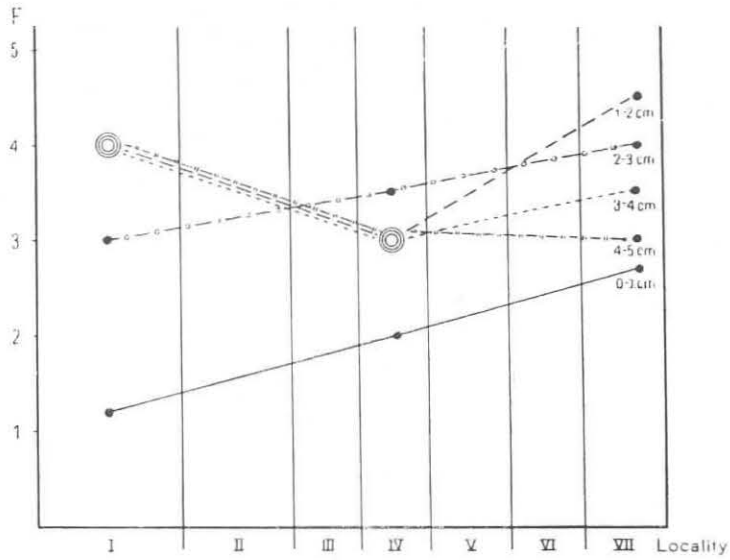

Fig. 22 $F = \frac{\text{free water p. c.}}{\text{humus p. c.}}$

F, on the other hand, (see Fig. 22) is surprisingly constant. At the outset it might have been expected that the ratio would increase rapidly towards Pl. VII, but here a rise is found in the very uppermost layer only, and none at all in the next. This means that during the greater part of the

year the soil is abundantly supplied with water and that each layer contains an average quantity of water, the size of which is for the most part dependent on the humus content. The low mean F-value in the uppermost layer at Pl. I (0-1 cm) perhaps indicates that in this layer the water content is essentially lower that in the other surface-layers, but it must be remembered that the root analysis here gives too high values (se pg. 176), and thus definite judging is impossible.

Summing up, it may be said that the mean water content of the samples, in this branch of animal ecology, does not indicate whether a locality is dry or moist, even though curves of these quantities may seem plausible. In plant ecology we have furthermore to operate with the total amount of water. In estimating the water content of a relatively coarse-grained sandy soil the ratio F $\left(\frac{\text{free water}}{\text{humus}}\right)$ should give a better idea of the actual facts. But in an atlantic climate like that of Denmark, the soil is only exposed to desiccation for short periods, so if we wish to get an idea of the moisture conditions of the localities we must consider the changes to which the water content is subject in the course of the year.

Before the curves of the changes in the water content of the soil strata are surveyed it will be of advantage to examine the water conditions in the extremely dry period at the close of July 1943. Table 5 gives information on this subject. From Pl. IV, 2 values are given; the first one is from the highest part (nearest Pl. I), the second from the lowest part of the locality. — It will be seen that, while the water percentage from Pl. I to the middle of Pl. IV remains very low, it suddenly rises about three times at Pl. V. If we consider the relative humidity, R. H., the facts are quite the same; values as low as 65 p. c. R. H. on Pl. I-III, a change at Pl. IV, and saturation in the lower-lying localities. — This agrees with KØIE's results from the layer 5-8 cm. While this layer dries up in the *Gnaphalium* zone, the relative humidity in the *Calluna* locality only decreases to 99,5 p. c. The content of organic matter is here 8 p. c.; this, at the same depth on the sampling line, corresponds to Pl. V, the relative humidity of which in the layer 1-3 cm at any rate does not fall below 96 p. c., but rather remains constant at 99-100 p. c.

Hence it will be seen that Pl. IV must be regarded as a transition locality between that part of the sampling line in which the water percentage in the dry period falls considerably below the critical value and that part of the line in which the water percentage always remains above this value. This agrees exactly with the fact that Pl. IV in the preceding section was regarded as a transition zone between the part af the Plain dependent on, and the part independent of the ground water. — The fact is that the ground water and

the organic substances together determine the water content of the localities; but if the ground water level has been lowered, for instance by draining, the metabolic conditions in the low-lying localities would be changed. The plants typical of moist soil would disappear, the amount of organic matter would decrease on account of the quicker metabolism, and the localities would gradually approach one another in appearance. In order to characterise briefly the difference between the high and the low-lying part of the Plain, I call the former the area independent of the ground water, and the latter the area dependent on the ground water.

In Fig. 14 (pg. 168) from August 1943 it is plainly seen that the vegetation above Pl. IV is scorched and withered, while the grass below is green and succulent.

It will now be of interest to calculate the ratio F in the dry period in the three chief localities of the Plain. Since the measurements of the water content and the relative humidity of the air refer to the layer 1-3 cm, the water percentage, root percentage, and humus percentage must be calculated for this layer as a whole. This can be done by the aid of Table 3.

Pl. I. Water p. c. 1, root p. c. 0,5. The root water percentage should then be 2 and the ratio would be negative. F cannot be calculated, for not only has the free water evaporated, but the roots have withered and dried up. The plant species characteristic of the dry locality are known to be able to tolerate such a desiccation (Simonis 1936). Only if the tip of the shoot dries up does the plant die.

Pl. IV, upper part. Water p. c. 6,2, root p. c. 1,5. Thus the root water should constitute 6 p. c., that is to say the greater part of the total amount of water, provided the roots do not dry up. When, however, the relative humidity is as low as 65-70 p. c. this is the case. Hence F cannot be calculated.

Pl. VII. Water p. c. 38, root p. c. 4,2, root water p. c. 17, i. e. the free water percentage = 21 p. c. Humus p. c. = 12, and F will then be about 1,8 as against the mean value 4-4,5.

Future investigations will show at what value of F the relative humidity of the air in the pores of the soil begins to decrease. Here we shall merely mention that Køie found the critical value of the water percentage to be about 8 in soil with an ignition loss percentage of 8. In the layer 5-8 cm the root content is very small as compared with the humus content, and thus the critical value of F approximately equals 1. — It must, however, be kept in mind that the dead organic matter differs in structure in the diverse localities, and this fact no doubt influences the size of the critical value.

5. The variations in the water content. Fig. 23 shows the variations in the water content in the layers 0-1, 0-5, and 5-10 cm on Pl. I-VII.

Fig. 24 show the water content in each of the layers 0-1, 1-2 ..... 4-5 cm in the same localities.

The presumed critical value in layers 0-1 cm and 1-2 cm has been marked as a horizontal line on Pl. I, IV, and VII.

It will be seen that roughly all the curves take the same course; the autumn of

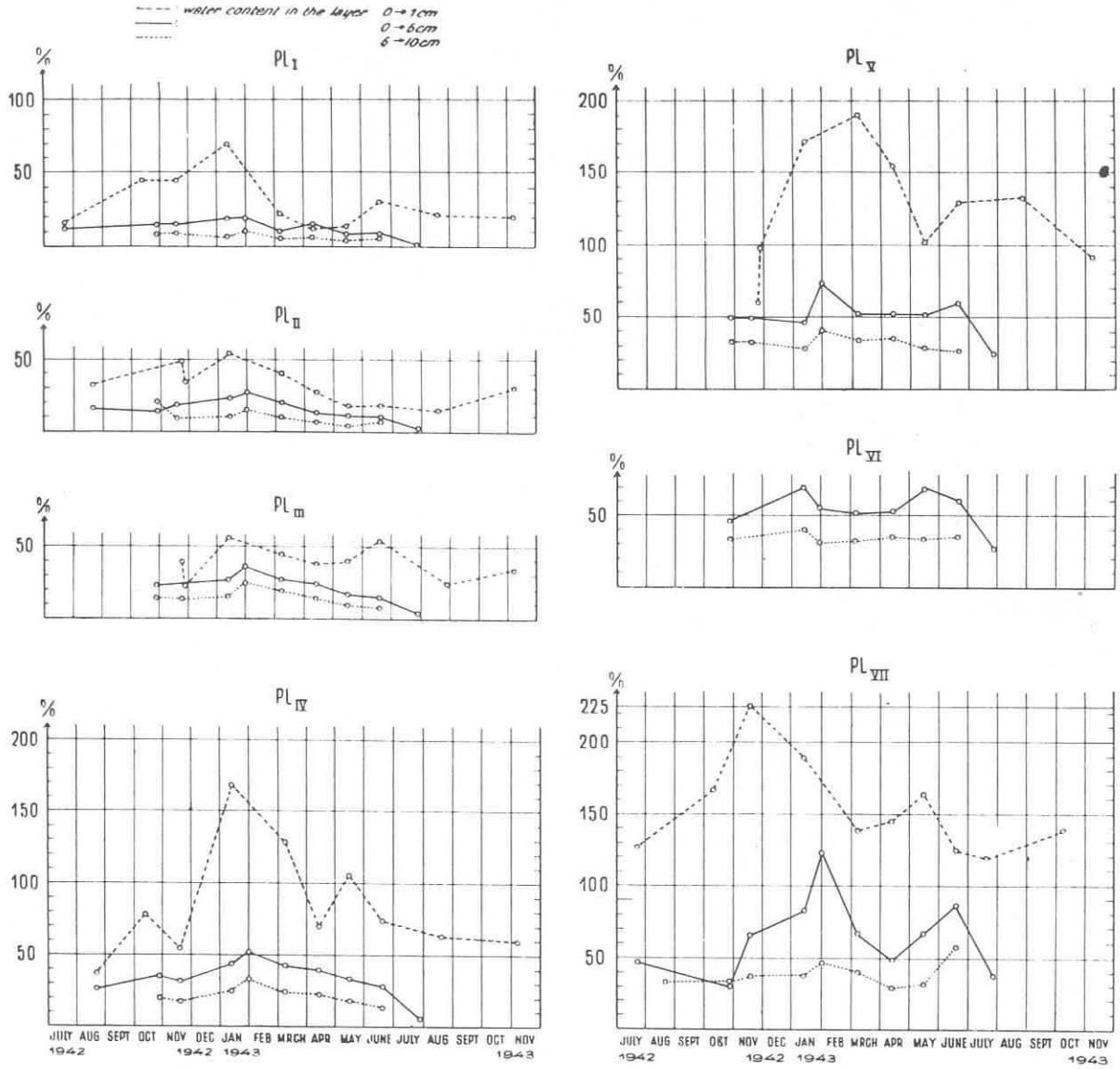

Fig. 23.

1942 had a very slight rainfall, and the maximum water percentage in October, when animal life reaches its maximum, did not increase, or showed only an insignificant rise. The increase is most pronounced in the uppermost layer and is no doubt due to a slighter evaporation in the autumn months. — The maximum water content is everywhere attained at the close of January 1943, when the Plain was flooded. — The water content in layers 0-5 and 5-10 cm then falls gradually again in the remaining part of the investigation period. The water percentage for the layers 0-1 and 1-2 cm in April and May even attains a relative

minimum and approaches the critical value, and it must be supposed that the drought of these months has been a contributory factor to the unusual

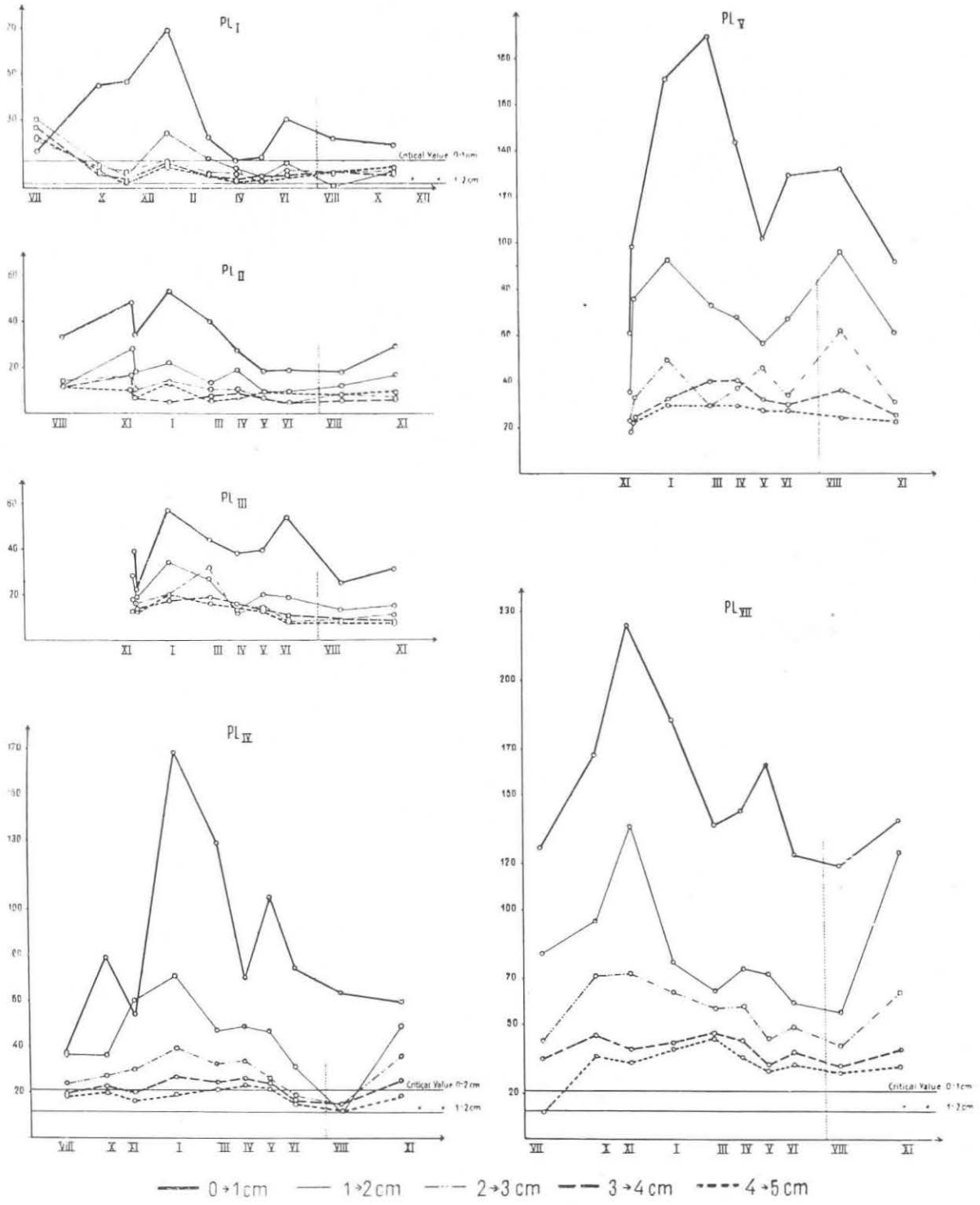

Fig. 24.

paucity of animal life in the whole of the spring and summer. — A more abundant rainfall in June caused the water percentage to rise again in several places. However, in the deeper layers this increase is only felt in the low-

lying localities. The rises recur on the southern line and on Rogeshøj. In all layers the minimum is attained in July and August. In July no BERLESE samples were taken, but the water conditions in this month have been mentioned in the preceding part. In Fig. 24 vertical lines have been marked in July to indicate that the curves here have a minimum, which would not otherwise be noticed.

Within the investigation period the months of April, May, June, July and August must be regarded as the critical months for animal life in the soil; the

Date	Localities						
	I	II	III	IV	V	VI	VII
12-1-43	Snow 1-2 cm Frozen 8 „	2-4 cm 5 „	3-4 cm 3-3½ „	8 cm 2 „	10 cm 1 „	10 cm unfroz.	10 cm unfroz.
31-1-43	4,0	4,0	4,0	4,0	4,0	4,0	4,0
7-3-43	6,3	6,2	4,5	5,8	4,5	4,5	4,5
11-4-43	11,3	10,5	10,0	9,6	9,4	9,5	9,4
15-5-43	16,3	15,3	14,0	13,9	13,4	13,3	13,5
17-6-43	20,5	20,0	18,7	17,3	16,9	17,9	17;7
18-8-43	18,5			17,8			16,5
7-11-43	4,4	4,8	5,1	5,5	5,8	5,9	6,0

Table 7

water percentage in the upper layers of the dry part of the Plain may then fall below the critical value.

6. The temperature. Table 7 gives the temperature (centigrades) at 1-2 cm depth measured at each sampling.

The values of the 31-1-43 for Pls. VI and VII indicate the temperature of the water. The measurements on the 15-5-43 were made at 8.55 p. m.

The measurements were made in the morning or in the evening, the values should therefore correspond approximately to the average temperature of the layers in the 24 hours in question. — As might be anticipated, the fluctuations are greatest in the high-lying localities. — On the 12-1-43 the ground on Pl. I was frozen to a depth of 8 cm, whereas Pls. VI and VII were not frozen. The winter of 1942-43 was mild and it is probable that the activity of the animals was only interrupted in the short frosty periods in January and February. It may be noted that AGRELL (1941, pg. 92) found that the resistance of the collemboles to low temperatures increases when winter approaches, and LINNANIEMI (1907, the winter fauna) and HANDSCHIN (1926) mentioned col-

lemboles on snow and ice. LINNANIEMI even shows that certain collembolan species propagate most abundantly in the winter months.

In the course of the spring and summer the temperature gradually rises. The difference between the high-lying and the low-lying localities is usually slight, but in the warm dry period in July and August it was very considerable (see table 5). While the temperature and the relative humidity of the air on Pls. I, II, and III at 5-6 p. m. were 35° C. and 65-70 p. c. R. H. respectively, the corresponding values for Pls. V. VI, and VII were 25° C. and 100 p. c. R. H. — In 1941 AGRELL ascertained the resistance to desiccation of some collemboles at 20° C. and 65 p. c. R. H. He found amongst other things that *Folsomia quadrioculata* which is typical of the dry part, under these experimental conditions had a resistance period of 14-18 minutes. The water vapour deficit at 35° C. and the same relative humidity of the air is however, considerably higher, and this emphatically points to the fact that the summer and the spring must be regarded as critical periods for the microfauna.

Judging from the measurements, the parts of the Plain dependent on and that independent of the ground water do not in other respects show any great differences.

DESCRIPTION OF THE REMAINING LOCALITIES

Southern line of the Plain, (Pl. A, B, C and D). Fig. 25. The line was laid out in the same way as the sampling line. The localities extend from the

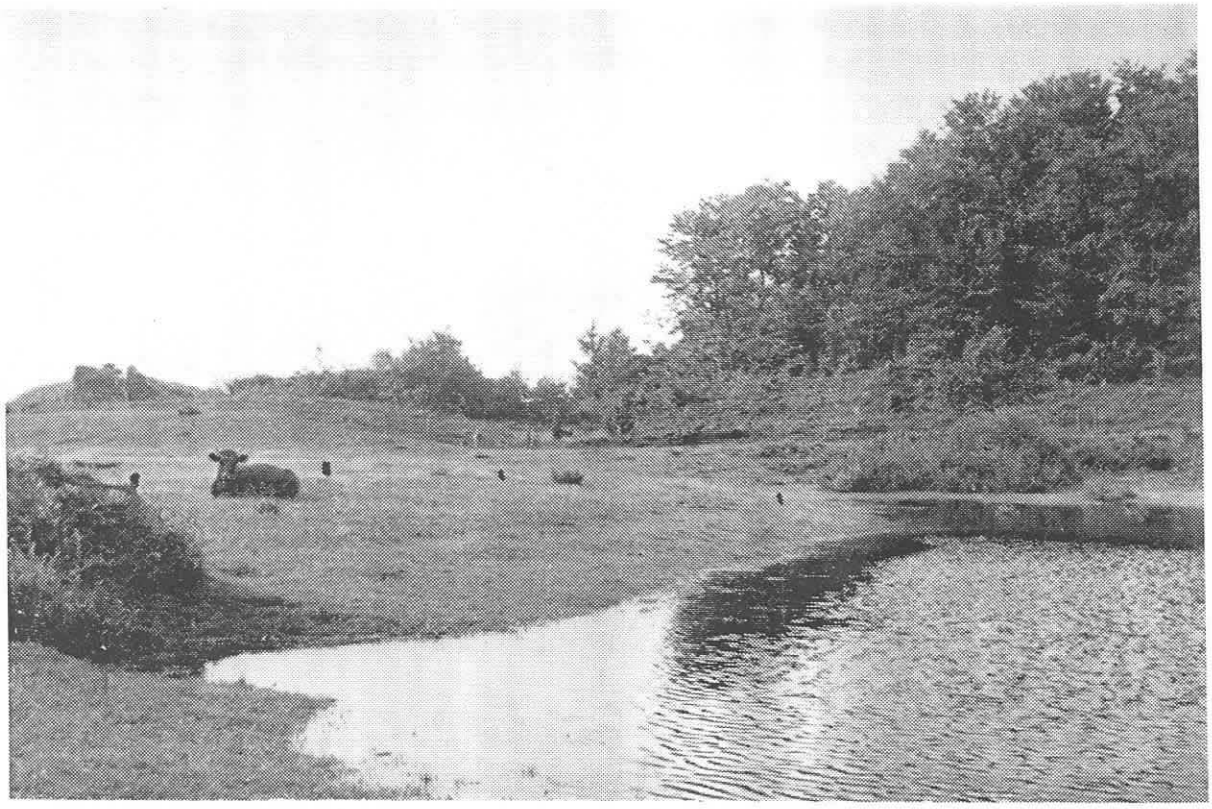

Fig. 25. Southern line of the Plain. (Thamdrup phot.).

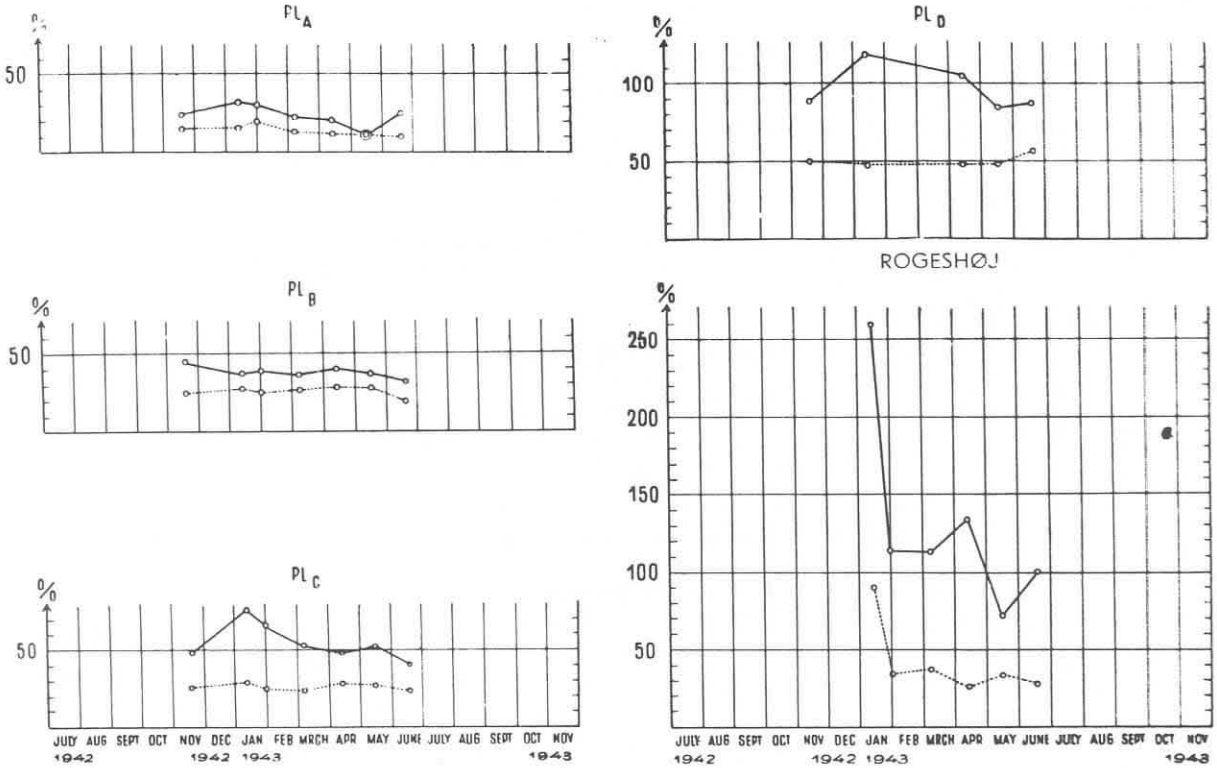

Fig. 26. Pls. A-D and Rogeshøj.
Water content.

dry *Gnaphalium* zone (A) through a low but fairly dense *Calluna* vegetation (B) over a *Calluna-Juncus squarrosus* zone (C) to the steeply sloping *Carex* zone (D). — In the inundation period the water covers the whole of locality D.

Even though this line was marked out in the same way as the sampling line, the localities in the two places are not quite comparable. The heather which extends into the *Gnaphalium* zone and forms an important component of the vegetation of the *Juncus* zone is avoided by the cattle and forms a thin raw humus yielding protection and a habitat to the animals. — *Juncus squarrosus* occurs in tufts, and the character plant, in addition to heather, is *Galium palustre*. Under the vegetation layer the soil is closely packed as on the sampling line.

The water content at 0-5 and 5-10 cm was measured from November 1942 to June 1943. (Fig. 26). — If we compare these curves with curves from the sampling line on the Plain, the two series of curves will be seen in the main to run parallel to each other, but the deflections on the southern line are relatively smaller for all localities, while the water percentage is throughout higher. — The higher water percentage is no doubt due to the fact that the soil, according to Mr. Køie's analyses, precisely in this part of the Plain is more fine-grained. In a *Carex vesicaria* vegetation corresponding to Pl. D the soil had the following composition:

Fig. 27. The Southern Meadow. (Thamdrup phot.).

46	p. c.	with	a	grain	size	of	0.6-2.0	mm
40	p. c.	-	-	-	-	-	0.1-0.6	-
8	p. c.	-	-	-	-	-	0.1-0.06	-
2	p. c.	-	-	-	-	-	0.06-0.02	-

If we consider the water percentage, the *Gnaphalium* zone on Pl. A corresponds to Pl. III and the *Calluna* zone on Pl. B to Pl. IV. The *Juncus* zone, Pl. C' corresponds most nearly to Pl. VI, whereas the *Carex* zone, Pl. D, seems to be more moist than Pl. VII. The vegetation on Pl. A, is exactly the same as on Pls I and II, and there is reason to suppose, therefore, that the difference in the average water content in the two localities is due to the difference in the grain size. Pl. B, on account of the heather, is not directly comparable with any of the other localities on the Plain. — The relatively small deviations of the curves may be due to the fact that the heather vegetation tends to lower the evaporation.

The Meadow, M, and the Southern Meadow, S-M. Fig. 27. These localities are situated close to the hills in the western part of the lowlying area in the same meadow, M in its northern, and S-M in its southern part. The meadow is sheltered by alder and ash hedges. — Haymaking takes place every summer; but otherwise the soil is not treated. The vegetation is tall and vigorous. In S-M the following plants occurred in June 1942: *Deschampsia caespitosa, Festuca rubra, F. elatior, Poa nemoralis, P. pratensis, P. trivialis, Holchus*

lanatus, Bromus mollis, Alopecurus uralensis, Carex stolonifera, Orchis latifolia. Cerastium caespitosum, Stellaria graminea, S. media, Lychnis flos cuculi, Rumex acetosa, Ranunculus acer, Caltha palustris, Cardamine pratensis, Filipendula ulmaria, Potentilla erecta, Geum rivale, Plantago lanceolata, Galium palustre, Myosotis hispida, Trifolium pratense, Rhinantus major, Brunella vulgaris. — Most of these plants only occur in moist or semi-moist meadows.

Profile: 0-70 cm dark layer, very rich in humus, then clean gray sand. Ground water level in January and April 1942 — 70 cm.

The uppermost 20 cm consists of loose mould rich in humus, and matted with roots. Passing downward the soil grows sticky and heavy, and at all depths there are rotten branches or bits of roots; alder and ash have previously grown in the locality.

There were many earthworms, the species *Lumbricus rubellus* being especially frequent. *Lumbricus terrestris* has been found in the deeper layers. — In other words the large burrowing species of earthworms are abundantly represented.

No measurements of the water content of the meadow were made, but the earth never dries up. As far as the water content is concerned, the meadow may be compared to that part of the Plain which is dependent on the ground water, apart from the fact that it is very seldom flooded. — The life conditions of the animals are, however, widely different in the two localities. Even though all the plants of the meadow have a vertical growth form, the exposed surface is nevertheless large, the stems of the tall vegetation being relatively widely spaced (except *Deschampsia caespitosa).* In addition the surface is loose and has a crumby structure; even fairly large mites and collemboles can therefore move about in the deeper layers.

Rogeshøj, H. Figs. 28-29. Rogeshøj is an old heather hill covered with large growths of juniper and bilbery on the north and east side. In the sampling locality the heather is dominant, and the ground vegetation consists of moss, especially *Dicranum scoparium.* — The hill has not been under cultivation within the memory of man, and the soil consists of a felty raw humus, bleached sand and a slight hardpan.

As is well known, heather humus is matted with roots (Raman 1911, pg. 195-98). The 2-3 uppermost centimetres of the raw humus are quite loose and consist of larger or smaller roots, leaves, and bits of branches, *Calluna* flowers and other small formed organic components. The content of formed remains decreases rapidly downwards, while the sand increases. The raw humus in the lower part is dark and dense without formed remains, but with a vigorously developed root-net. Table 4 shows that the relative humidity of the air in the pores never drops below about 99 p. c. The raw humus of Rogeshøj must therefore be regarded as a permanently humid habitat. Fig. 26 shows

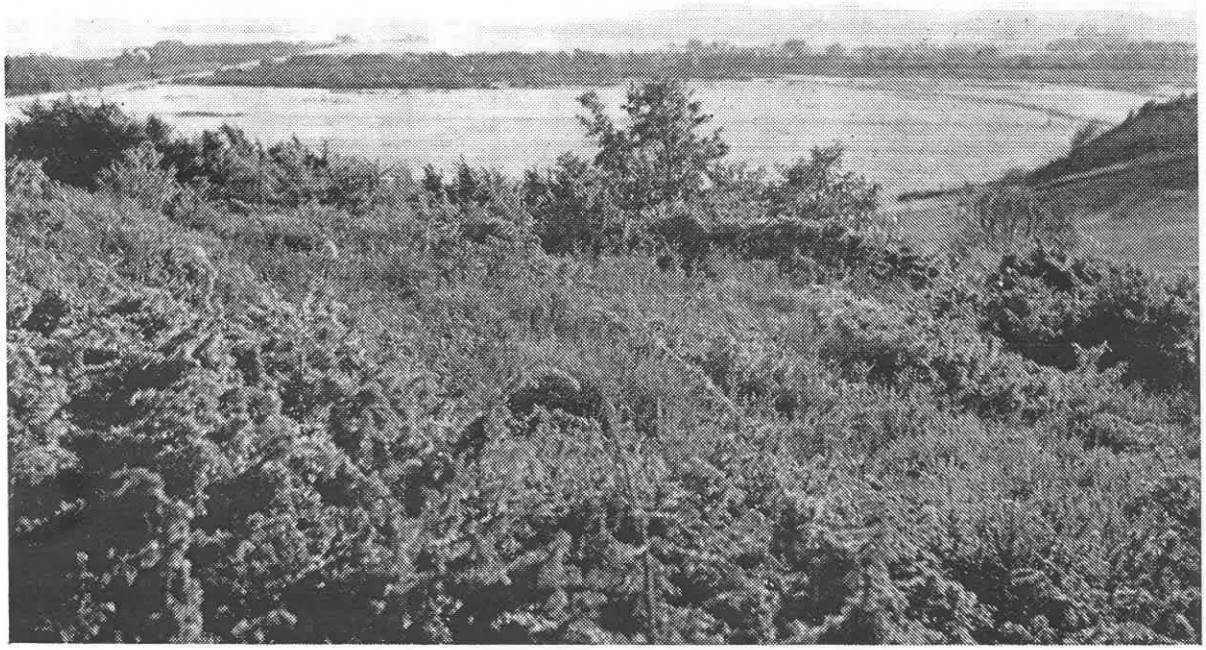

Fig. 28. Rogeshøj. (Thamdrup phot.).

Fig. 29. Rogeshøj. Close up picture of the surface layer. (Thamdrup phot.).

Fig. 30. Revlinghøj. Close up picture of the moss cover. (Thamdrup phot.).

the water content. — It is known that *Dicranum scoparium* will tolerate desiccation, and the moss layer dries up in the warmest period.

The very large content of more or less decayed organic remains, the loose structure, and the constant moisture conditions are characteristic of the upper layers of the raw humus.

Revlinghøj, R. Fig. 30. Revlinghøj (»Empetrum-hill«) is a low freely exposed heather hill which was under the plough about 20 years ago. Since then it has been untouched. It is covered with low scattered heather bushes among which may be found small carpets of *Empetrum nigrum*. The ground vegetation (Fig. 30) consists of *Stereodon cupressiforme* and *Cladonia* species. In several places the sand comes up to the surface. — The hill is much exposed to wind and desiccation.

Profile: 0—2-3 cm light holey heather humus.

2—22 cm grey slightly humous sand, and below red sand.

The raw humus is matted with roots. It contains many formed components and passes imperceptibly into the grey sand.

The moss dries up entirely in the summer; but we have no measurements of the water content neither of the moss nor the raw humus. In the dry period the raw humus is as dry as dust, and it is probable that the relative humidity of the air in its upper loose parts falls considerably below 100 p. c.

DESCRIPTION OF THE FAUNA

The survey of the microfauna of the individual localities is divided into the following sections:

1. The samples and the species.
2. The sampling line.
   a. The total fauna of the localities, dominant and characteristic species, and erection of communities
   b. The vertical distribution of the species, the subterranean species.
   c. Variations of the fauna in the course of the year.
3. The remaining localities. Supplementary samples.

THE SAMPLES AND THE SPECIES

As already stated, samples were taken from the Plain at regular intervals. From the localities Pls I, IV and VII 10 series of 5 samples each were analysed. The samples from Pls II, III and V were either taken at the same date or within 4 or 5 days; 8 series from each of these localities were analysed. Thus a total of 270 samples from the sampling line has been analysed.

Pls I, IV, VII:

1942: 19/7, 13/10, 19/11.

1943: 12/1, 7/3, 11/4, 15/5, 17/6, 18/8, 7/11.

Pls II, III, V:

1942: 18/10.

1943: 12/1, 7/3, 11/4, 15/5, 17/6, 26/8, 7/11.

The interval from the 12/1 to the 7/3 may seem rather long, but it was not until the beginning of March that the frost finally ceased.

Further, a good deal of supplementary material was examined:

1. Qualitative samples from frozen ground and vegetation from the dry part. 3 samples. 16/1 1942.
2. The Plain, Pl. Two moist localities, one of which was flooded. — 3/4 1942, thaw. 11 samples.

3. Southern line of Plain. 15 samples from the *Gnaphalium*, *Calluna* and *Juncus* zones. 29/7 1943.
4. The Meadow, M. Samples in and outside a grass tussock and from deeper layers, 7 samples. January and April 1942.
5. The Southern Meadow, S-M. 4 samples from the soil between the vegetation. 30 6 1942.
6. Rogeshøj, H. 5 samples from moss and raw humus. 8/7 1942.
7. Revlinghøj, R. 4 samples from moss, raw humus, and bleached sand. 1/4 and 30 6 1942.

A total of 322 samples from the area was analysed. It should be noted, however, that animals were not found in all the samples.

The species found. The lists of species comprises 145 identified animals, and the rest have been grouped together in 36 groups. A group may consist of unidentified species of an identified genus (e. g. *Tarsonemus* species), or it may be a larger unit (e. g. *Chironomidae* larvae). If a number follows the group name it means that the individuals of the group belong to well characterised species which it has not yet been possible to identify.

The species are distributed as follows.

	Number of genera identified
Gamasidae: 17 species	16
Trombidiformes: 45 species	
Tarsonemini: 11 species	8
Endeostigmata: 4 species	4
Prostigmata: 30 species	23
Oribatidae: 53 species	33
Acaridiae: 4 species	6
Collembola: 26 species	20

The list of species is found in Table 8 in connection with a survey of the occurrence of the species in the localities. The figures indicate the total number of individuals found of the species in question in the various localities.

It has not been possible to identify the following species. The description will be found in the Appendix.

These n. spp. are:

Gamasidae: Vitzthumia magniscutum, Arctoseius bispinatus.

Tarsonemini: Tarsonemoides belemnitoides, T. brevilobus and *Tarsonemoides monoporus.*

Endeostigmata: Terpnacarus subterraneus.

Prostigmata: Tydeus tridactylus and *Cocceupodes paradoxus.*

Oribatei: Brachychthonius furcatus, Br. cricoides.

Table 8

	Pl. I	Pl. II	Pl. III	Pl. IV	Pl. V	Pl. VII	Plain Dry	Plain Moist	Southern Sample line on the Plain			Meadow	Southern Meadow	Revlinghøj	Rogeshøj
									Gnaphalium A	Calluna B	Juncus C	M	S-M	R	H
Collembola															
Hypogastrura armata. NICOLET. 1841	6	9	3	2	2	12		5				4	69		
Schøtella parvula. SCHÄFFER. 1896					1	1							1		
Xenylla maritima. TULLBERG. 1869				1		3									3
— *humicola*. FABRICIUS. TULLBERG. 1876															
— *börneri*. AXELSON. 1905	1														
Frisea mirabilis. TULLBERG. 1871												1			
Micranurida pygmaea. BØRNER. 1901															1
Anurida granaria. NICOLET. 1847															1
Onyschiurus armatus. TULLBERG. 1869												7			4
Tullbergia krausbaueri. BØRNER. 1901	49	39		2	8	6	2	10				18	4		
Pseudachorutes. corticicola. SHÄFFER. 1896							3								
Isotomodes productus. AXELSON. 1906	3														
Folsomia quadrioculata. TULLBERG. 1872	128	71	24	55	24	11	9	38	1	2	4				12
— *fimentaria*. TULLBERG. 1872												5			
Proisotoma minima. ABSOLON. 1901						4						24			
Isotoma notabilis. SHÄFFER. 1896					4	1									
— *viridis*. SCHØTT. 1893	14	2	7	5	3	4				2			6	1	
— *violacea-olivacea*. TULLBERG	4					1									
— *minor*. SHÄFFER, 1896						3							1		
Isotomurus palustris. MÜLLER. BØRNER. 1903													1		
Entomobrya sp.					1										
Sira platani. NICOLET. 1841	3			2					1		1				1
Lepidocyrtus cyaneus. TULLBERG. 1871	2	1		1		1				1	1		1		
— *lanuginosus*. TULLBERG. 1871												1	1	2	1
Sminthurinus aureus. LUBBOCK. 1862	1							6							
Deuterosminthurus bisinctus. KOCH. 1840													1		
Gamasides															
Pergamasus runcatellus. BERLESE. 1903			3	3	2	8							1		

Pergamasus crassipes. LINNE. 1758			4	1	3	1										
— *primitivus.* OUDEMANS						3										
Amblygamasus septentrionalis. OUDEMANS																1
1902. *var. norvegicus.* BERLESE. 1905																
Digamasellus angulosus. WILLMANN. 1936					2	1						2				
— *Nr. 4*	1	2					9									
Asca nova. WILLMANN. 1939		3	1				3	1			1					
Veigaia kochi. TRÄGÅRDH. 1902.																1
Vitzthumia magniscutum n. sp.	2		1				1									
Pachylælaps longisetus. HALBERT. 1915																1
Arctoseius bispinatus n. sp.	6	6	7		1	12										
Ololælaps hemisfæricus? C. L. KOCH. 1839		4	1					1								
Lasioseius				1												
Copriphis sp.			1													
Amblyseius obtusus. C. L. KOCH	1															
Hypoaspis sp.						1										
Lælaptid No. 2					1	5	2	2		1			1			
— — 5						1										
— — *11*	1															
Rhodacarus roseus. OUDEMANS. 1902										2				2	1	
Zercon suecicus. SELLNICK. See FORSSLUND 1943					6	3										
— *curiosus.* TRÄGÅRDH. 1910														1	2	
— *radiatus.* BERLESE. 1910														1		
— *sp.*				1			1									
Cilliba cassidea. HERMANN. 1804					2	2			1			4				
Undeterminated Gamasidae and -larvae	1+2	2		3	2	1	1			2		6	6	4		
Trombidiformes																
Variatipes quadrangularis. PAOLI. 1911	47	17	13	2		1	6	8			12	3	22			
— *eucomus.* BERLESE. 1908													1			
— *tridentinus.* PAOLI. 1911		1											5			
Imparipes hystricinus. BERLESE. 1903													1			
Scutacarus crassisetus. var. plumosus. PAOLI. 1911	1							1				2	3			
Diversipes exhamulatus. MICHAEL. 1896																3
— *sp.*												1				

	Pl. I	Pl. II	Pl. III	Pl. IV	Pl. V	Pl. VII	Plain Dry	Plain Moist	Southern Sample line on the Plain			Meadow	Southern Meadow	Revlinghøj	Rogeshøj
									Gnaphalium A	Calluna B	Juncus C	M	S-M	R	H
Pygmephorus spp.	1		2					1				5	4		
Pediculopsis graminum. REUTER. 1900															
Tarsonemus spp.		3	1	6											2
Tarsonemoides uliginosus. WILLMANN. 1942							1								1
— *belemnitoides n. sp.*	1	1	2			4					6				
— *brevilobus n. sp.*	1	1	4	3				1					1		
— *monoporus n. sp.*						1									
Undeterminated Tarsonemus spp.		1				3									
Alicorhagia fragilis. BERLESE. 1910		1			1			1					4		1
Terpnacarus subterraneus n. sp.		8	2		4			1							
Nanorchestes arboriger. BERLESE. 1905	28	8	1	3	2	1		3					1	8	20
Speleorchestes termitophilus. TRÄGÅRDH. 1910	2														
Rhagidia mordax. OUDEMANS. 1906	1														
Tydeus croceus. C. L. KOCH. 1836												2			
— *hyacinthi.* OUDEMANS. 1932	2		1	4	1	1		1							
— *xylocopae.* OUDEMANS. 1926		2	1		1										
— *tridactylus n. sp.*	1	2	3	3		1	31							1	4
Brachychtydeus breviculus. KOCH. 1838						1									2
Coccotydeus frequens. GRANDJEAN. 1938	9	1	3										1	3	9
Triophtydeus pinicolus. OUDEMANS. 1929	1			1										9	
Microtydeus fenilis. CANESTRINI. 1886	10		1			1	2	1						2	1
— *similis.* — —							1								
Retetydeus catenulatus. THOR. 1931															20
Lorrygia reticulata. OUDEMANS. 1928	1		1	2	1			1							
Rhaphitydeus raphignatoides. BERLESE. 1910														2	
Undeterminated Tydeidae				2									1		
Ereynetes sp.		1		1		1									
Eupodes voxencollinus. THOR. 1934												3			
— *viridis.* OUDEMANS. 1906	1														
— *berlesei.* THOR. 1912	6	1		4							1		1		2

Coccupodes clavifrons. CANESTRINI. 1886														1	
— *paradoxus n. sp.*	2	7	3		2			1					1		
Protereunetes borneri. THOR. 1934	5	3			1										
Undeterminated Eupodes spp.						2			1					1	1
Stigmaeus cutricus. BERLESE. 1910												2			
— *sp.*	2			1			3	5							
Macrostigmaeus sp.													1		
Ledermülleria plumifer. HALBERT. 1923								1							1
Podaia siculus. BERLESE										1					
Bryobia praetiosa. C. L. KOCH. 1836.	5	2	2	3		7	1	1							
Undeterminated Tetranychidae.						2									
Cheyletes eruditus. SCHRANK. 1781				1											
Bdella lignicola. C. L. KOCH. 1836	1		1	1					1						
— — *larvae*	3														
— *spinirostris*. C. L. KOCH. 1836														1	
— *semiscutata*. THOR. 1930												1			
Cyta latirostris. HERMANN. 1804	2								1		1		1	1	3
Eupalus coecus. OUDEMANS. 1931	2	1													
Belaustium rubripes. TROUESSART				1			1								
— *sp.* 1, 2				×				2							
Undeterminated Prostigmata.	1	6											1	2	18
Oribatei															
Eulohmannia ribagai. BERLESE. 1910												1			
Nanhermannia elegantula. BERLESE. 1913													2		
Brachychthonius sellnicki. THOR. 1930	16	13	4			6	1	2		1		5			1
— *perpusillus*. BERLESE. 1910												4		4	7
— *brevis*. MICHAEL. 1888								1						7	13
— *furcillatus*. WILLMANN. 1943								3							2
— *sp.*															×
— *sp.*														1	
— *berlesei*. WILLMANN. 1936	13	7				1						2			
— *cricoides n. sp.*														8	32
— *bimaculatus*. WILLMANN. 1936	4		1	6			7								
furcatus n. sp.	11	8	1	9			23			•					
— *zelewaiensis*. SELLNICK. 1928															13

	Pl. I	Pl. II	Pl. III	Pl. IV	Pl. V	Pl. VII	Plain Dry	Plain Moist	Southern Sample line on the Plain			Meadow	Southern Meadow	Revling høj	Roges høj
									Gnaphalium A	Calluna B	Juncus C	M	S-M	R	H
Malaconothrus globiger. TRÄGÅRDH. 1910					1	93							24		1
Nothrus silvestris. NICOLET 1855															29
Platynothrus pellifer. C. L. KOCH. 1840					29	6		16					13		
Belba pulverulenta. C. L. KOCH. 1840												2			1
Licneremaeus licnophorus. MICHAEL. 1882															1
*) *Suctobelba species*								3				3		11	41
— *trigona.* MICHAEL 1882								7							6
Oribella paoli. OUDEMANS. 1913												1	2		
Oppia clavipectinata. MICHAEL. 1885	4	9	1	1	1	9						3			1
— *neerlandica.* OUDEMANS. 1900				3		1						9	1	2	
— *minus.* PAOLI. 1908	3	1		2				3			6				22
— *splendens.* C. L. KOCH. 1840														2	12
— *quadricarinata.* MICHAEL. 1885														5	1
— *fallax.* PAOLI. 1908								1							
— *sp.*		2													
Ceratoppia bipilis HERMANN. 1804									2	1					1
Scutovertex minutus. C. L. KOCH. 1836	1	5		2				2			2	1			
Tectocepheus velatus. MICHAEL. 1880	22	57	35	45	52	54	49	15	5	20	22	6	11	24	13
Odontocepheus elongatus. MICHAEL. 1879															2
Carabodes marginatus. MICHAEL. 1884								3		3					
Liacarus coracinus. C. L. KOCH. 1840											1	1			1
Oribatula venusta (see FORSSLUND 1943)														4	2
Oribatella berlesei. MICHAEL. 1898												9			
Ceratozetes gracilis. MICHAEL. 1884															3
Minunthozetes semirufus. C. L. KOCH. 1840													1		
Trichoribates trimaculatus. C. L. KOCH. 1836	2			1		1			1						8
— *incisellus.* KRAMER. 1897	1	2	2	1	1										
Scheloribates laevigatus. C. L. KOCH. 1836		1		7	16	24	1	34			1	9	8		
— *pallidulus.* C. L. KOCH. 1840														8	3
Punctoribates punctum. KOCH. BERLESE. 1840. 1888												5			
Liebstadia similis. MICHAEL. 1888										1	2	21	2		

* Following species are determinated: *S. falcata* (H. Samp. 6), *S. intermedia* (R. Samp. 5), *S. sarekensis* (H. Samp. 1 and 6), *S. subcornigera* (H. Samp. 6), *S. sp.* (n. sp. R. Samp. 5).

Notaspis coleoptratus. LINNÉ. 1758													3	1		19
Pelops planicornis. SHRANK. 1803						1				1						
— *ureaceus.* C. L. KOCH. 1840													2			
Peloptulus phaenotus. C. L. KOCH. 1844	1		3	9		2		4								
Galumna tenuiclavus. BERLESE. 1908					1											5
— *nervosus.* BERLESE. 1914													1			
— *sp.*													2			
Pthiracarus piger. SCOPOLI. 1763													10			
Hoploderma striculum. C. L. KOCH. 1836																2
Oribotritia loricata. RATHKE. 1799													38			
Pseudotritia monodactyla. WILLMANN. 1920						1										
Oribatid-nymph No. 4													2			
— — — *9*																
— — — *10*	1		2	1				1								
— — — *14*																
Acaridiae																
(Tyroglyphus farinae. LINNÉ. 1758*)*	x	x	x	x	x	x		x								
(Oudemansium domesticum. DE GEER. 1798*)*	x	x	x	x	x	x										
Tyroglyphus longior. MICHAEL.			1			4										
Swiebia talpa. OUDEMANS. 1916						5		4						4		1
Calvolia. Deutonymphs	6			2		9										
Cerophagus. —				1												
Anaetus. —													1			
Tyroglyphin. —								9					64			
Undeterminated Tyroglyphinae	7	2	1	5	4	4	1									
Enchytraeidae	1				3	15							{ 1	6	1 }	
Nematodes	2	1	7	5	5	3				1				3		
Chantaridae. Larvae																
Staphylinidae. —	5	6		1										1		
— *Adults*			1													
Chironomidae. Larvae	32	26	7	23	5	3		1						3	1	
— *Adults*	1	1		3		1				2						
Diptera. Larvae	3		1		5	4				1				1		
Lepidoptera. Larvae	2		1													
Tripidae	1			1		1			1							
Troctidae	1	1	2	5		1										
Pseudococcinae.	24	1	1			3									3	2
Various	4	6	2	4	1	5									1	

Juvenile forms. The young of the *collemboles* resemble the adults, but have a relatively larger head, more powerful limbs, and a less marked colour pattern. The characters differentiating the species are not always developed; the identification, however, did not cause any great difficulty.

The juvenile forms of the *Gamasidae* resemble the adults a good deal.

The juvenile forms of the *Trombidiformes* likewise, as far as the groups here treated are concerned, resemble the adults, and it may often be difficult to decide whether one has a nymph or a mature animal before one. Only an examination of the genital region can settle this question. — It should be noted that the *Scutacaridae* have one larval and no nymphal stage.

The larvae and nymphs of the *Oribatidae* differ considerably in appearance from the adults. The nymphs of the following species have been taken into consideration: *Malaconothrus globiger*, *Platynothrus peltifer*, *Tectocepheus velatus*, *Scutovertex minutus*, *Scheloribates laevigatus*, *Liebstadia similis* and *Peloptulus phaenotus*.

The *Acaridiae* are represented by *Tyroglyphidae* and their juvenile stages, especially the heteromorphic deutonymphs. These deutonymphs have only been determined as to genus, the adults being unknown.

Special remarks. Among the adult *Tyroglyphidae* we shall here briefly discuss the species *Tyroglyphus farinae*, *T. longior* and *Oudemansium domesticum (= Glycyphagus d.)* — These species are found in many places, inter alias in houses. While *Tyroglyphus longior* occurs fairly equally in the samples and must no doubt be included in the terrestrial fauna (found in soil by MICHAEL 1897 and SCHWEIZER 1922), *Tyroglyphus farinae* and *Oudemansium domesticum* occur especially in the November samples from 1942 and 1943, whereas no large amount of nymphs was found in the intervening period. — At this time a couple of packets of oatmeal left in the laboratory were invaded by these very species and they may therefore be assumed to have wandered into the BERLESE apparatus in great number during the driving out. Sic.

Sira platani, which is included in the xerophilous hemiedaphon (GISIN), was found in a few samples at 3-5 cm depth. The species is not able to move at all in these layers of the soil, and must have jumped into the sieves during the driving out. This species too is well known from houses and other dry localities. — The same applies to the sparsely occuring *Troctidae*.

The number of *Tyroglyphus farinae* and *Oudemansium domesticum* is stated at the bottom of the tables and is not included in the total.

Nematodes and *Enchytraeidae* frequently occured in the samples; but their number does not indicate their frequency in the soil, since these animals cannot be expelled by means of the BERLESE apparatus (cf. TRÄGÅRDH and FORSSLUND 1932 pg. 44 and FORSSLUND 1943 pg. 93, OVERGAARD 1948).

THE SAMPLING LINE

INTRODUCTION

The relative frequency of the species was calculated. As already mentioned, the numerical material is small, but this drawback is in some degree balanced by the fact that samples were taken almost simultaneously from all the localities and that the latter pass gradually into each other. — Supplementary samples from other localities on the Plain show that many of the animal species found are characteristic of the various localities, even though there is room for variations.

The number of animals in the different samples is seen in Tables 9-15. They require no further explanation.

In the Table 17 all the dominant, influent, constant, and accessory species are reviewed (explanation see pag. 146).

The frequency percentage and the average number of animals per 1/1000 sq.m of the surface has been calculated for the various species.

As it is seen, the amount of the above-mentioned species constitutes 2/3 or more of the total fauna and a survey of this selection should therefore give an impression of the fauna as a whole.

Table 16 shows the proportion of the various groups in the total fauna expressed in per cent. The percentage of the *Collembola, Trombidiformes* and *Oribatidae* decreases or increases gradually as we pass from one end of the line to the other. If we exclude Pl. III, this applies to the *Gamasidae* too.

Plain	Number per series	Total number	*Collembola* p.c.	*Gamasidae* p.c.	*Tarsonemini* p.c.	Other *Trombidiformes* p.c.	Total *Trombidiformes* p.c.	*Oribatidae* p.c.
I	47	520	39	2.7	10	16	26	15
II	40	342	36	5	7	12.7	20	31
III	21	170	20	10	13	11	24	31
IV	25	270	25.2	3.3	5.5	8.8	14	32
V	25	205	20.5	9.3	3	6.3	9.3	49.7
VI	34	377	12.4	9.0	2.4	5	7.4	56

Table 16

THE FAUNA OF THE INDIVIDUAL LOCALITIES

Pl. I. 11 series of 1/1000 sq. metre.

Total number of individuals: 529, i. e. 48 per 1/1000 sq. m.

Folsomia quadrioculata, Tullbergia krausbaueri, the small *Variatipes quadrangularis (Scutacaridae)* and the saltatory mite *Nanorchestes arboriger* are dominant and constant.

The localities / The species	Pl. I 48 individuals per 1/1000 sq.m.			Pl. II 44 individuals per 1/1000 sq.m.			Pl. III 21 individuals per 1/1000 pc.			Pl. IV 24 individuals per 1/1000 sq.m.			Pl. V 25 individuals per 1/1000 sq.m.			Pl. VII 34 individuals per 1/1000 sq.m.		
	Relative frequency in pc.	Constancy pc.	Average number per series	Relative frequency in pc.	Constancy pc.	Average number per series	Relative frequency in pc.	Constancy pc.	Average number per series	Relative frequency in pc.	Constancy pc.	Average number per series	Relative frequency in pc.	Constancy pc.	Average number per series	Relative frequency in pc.	Constancy pc.	Average number per series
Tullbergia krausbaueri	**9,2**	82	4-5	**11,5**	88	5		38			27		4	50	1			
Hypogastrura armata				3	50											3	27	1
Xenylla maritima																	27	
Folsomia quadrioculata	**25**	82	11	**21**	38	9	**14**	100	3	**20,4**	91	5-6	**12**	88	3	3	55	1
Isotoma viridis	2,7	27	1								36						36	
— *minor*																	27	
Arctoscius bispinatus		27					4	38	1							3	64	1
Pergamasus runcatellus											27							
Asca nova					38													
Zercon suecicus													3	38	1			
Microtydeus fenilis		28	1															
Variatipes quadrangularis	**9**	55	4	**5**	50	2	**8**		2									
Terpnacarus subterraneus				2	50	1												
Nanorchestes arboriger	**5,4**	64	3	2		1												
Tydeus tridactylus								38										
Coccotydeus frequens		36	1															
Eupodes berlesei		27	0-1								36							
Cocceupodes paradoxus				2	62	1											27	
Tarsonemus spp.										2,2								
Brachychthonius bimaculat.										2,3	27						27	
— *sellnicki*	3	46	1-2	4	62	1-2												
— *berlesei*	2,5	46	1	2		1												
— *furcatus*		36	1	2		1				3,3	27	1						
Malaconothrus globiger																**25**	45	8-9
Platynothrus pellifer													**14**	63	3-4			
Oppia clavipectinata				3	50	1										2,5	36	1
Scutovertex minutus					50													
Tectocepheus velatus	4,2	82	2	**17**	100	7	**20**	100	4	**16,3**	81	4-5	**26**	100	6-7	**17**	91	6
Scheloribates laevigatus										2,7	45	1	**8**	75	2	**8**	82	2-3
Peloptulus phaenotus								38		3,3	55	1						
Pseudococcinae	4,6	27																
Staphylinidae larvae																	36	
Chironomidae larvae	6	27	3	2	63	1	4		1	8,5	27	2						
Other *Diptera larvae*													2,5	38				

Table 17

The *Chironomidae* larvae have a high frequency percentage, but only occurred in three of the series. MORRIS (1922) found that the occurrence of these animals in arable land is contingent upon the presence of stable manure. It

Dominant	%	Constant	%
Folsomia quadriocul.	25	*Tullbergia krausbaueri*	92
Variatipes quadrang.	9	*Folsomia quadriocul.*	82
Tullbergia krausbaueri	8	*Variatipes quadrang.*	55
Chironomidae larvae	6	*Nanorchestes arboriger*	64
Nanorchestes arboriger	5.4	*Tectocepheus velatus*	82
Influent	**%**	**Accessory**	**%**
Pseudococcinae	4.6	*Isotoma viridis*	27
Tectocepheus velatus	4.2	*Arctoseius bispinatus*	27
Isotoma viridis	2.7	*Coccotydeus frequens*	36
Brachychthonius selln.	3	*Eupodes berlesei*	27
— *berl.*	2.5	*Brachychthonius selln.*	46
		— *berl.*	46
		— *furc.*	36
		Chironomidae larvae	27
		Pseudococcinae	27

is possible, therefore, that the animals are found in great numbers by or in old cow dung. At any rate, they occur very irregularly. Thus more than 5/6 of the individuals were found in a single sample from the 12/4 1943, and so it is important to take dominance and constancy into account when a fauna is to be characterised. The *Pseudococcinae* show the same scattered occurrence.

Tectocepheus velatus is influent but constant. *Brachychthonius sellnicki*, *Br. berlesei* and *Br. furcatus* were found regularly, but the *Oribatidae* only constitute 15 p. c. of the total fauna. Of these the small *Brachychthonius* species form a half and *Tec. velatus* a fourth. — The large oribatid species are rarely seen *(Scutovertex minutus)*. — The more frequent are the *Trombidiformes*. They constitute 26 p. c. in all and are represented by 25 species. As previously mentioned, *Variatipes* and *Nanorchestes* dominate; *Coccotydeus frequens* and *Eupodes berlesei* are accessory species, the rest of the *Trombidiformes* occur scattered now and then. The presence of the *Tydeidae* and *Eupodidae* must be noted.

The number of *Gamasidae* is small. *Arctoseius bispinatus* and *Vitzthumia magniscutum* are noteworthy as being almost the only representatives of these predatory mites.

Pl. II. 8 series.

351 individuals in all = 44 per 1/1000 sq. m.

The fauna is much like that of Pl. I. Here too, *Folsomia quadrioculata* is a dominant species; but curiously enough, it was absent from all spring and

Dominant	%	Constant	%
Folsomia quadriocul.	21.0	*Hypogastrura armata*	50
Tectocepheus velatus	17	*Tectocepheus velatus*	100
Tullbergia krausbauri	11.5	*Tullbergia krausbaueri*	88
Variatipes quadrang.	5	*Variatipes quadrang.*	50
		Brachychthonius selln.	62
		Cocceupodes paradoxus	63
		Terpnacarus subterran.	50
		Oppia clavipectinata	50
		Scutovertex minutus	50
		Staphylinidae larvae	50
		Chironomidae larvae	63

Influent	%	Acessory	%
Brachychthonius selln.	4	*Folsomia quadriocul.*	38
Hypogastrura armata	3	*Asca nova*	38
Oppia clavipectinata	3	*Nematodes*	38
Terpnacarus subterran. ca.	2	Mixed	38
Nanorchestes arboriger ca.	2		
Cocceupodes paradoxus ca.	2		
Brachychthonius berl.	2		
— *furc.*	2		
Chironomidae larvae	2		

summer samples from 1943. *Tullbergia krausbaueri* and *Variatipes quadrangularis* are dominant and constant, whereas *Nanorchestes arboriger* is only an influent species here. — In the denser vegetation the number of *Oribatidae* has increased. They now constitute 30 p. c. of the total fauna, and half of them are *Tectocepheus velatus*, which dominates and whose constancy percentage is 100. In the rest of the localities this species is dominant. The *Brachychthonius* species constitute about one fourth of the oribatid fauna. *Br. sellnicki* is constant. — *Scutovertex minutus* is the only large oribatid; it was found in half of the series.

On Pl. II the *Trombidiformes* constitute 20 p. c. only of which *Variatipes quadrangularis* constitutes 5 p. c. The rest is chiefly *Tydeidae* and *Eupodidae*. *Cocceupodes paradoxus* and *Terpnacarus subterraneus* deserve special mention. These two occur in half of the samples.

Pl. III. 8 series.

Total: 166 individuls = 21 per 1/1000 sq. m.

From this locality only 166 animals were identified and the fauna is somewhat different from that of the dry localities. Thus the *Gamasidae* constitute about 10 p. c. of the total amount of animals but this may be accidental.

Dominant	%	Constant	%
Tectocepheus velatus	20	*Tectocepheus velatus*	100
Folsomia quadriocul.	14	*Folsomia quadriocul.*	100
Variatipes quadrang.	8	*Nematodes*	62
Influent	**%**	**Accessory**	**%**
Arctoseius bispinatus	4	*Arctoseius bispinatus*	38
Chironomidae larvae	4	*Hypogastrura armata*	38
Nematodes	4	*Tydeus tridactylus*	38
		Peloptulus phaenotus	38

The dominant species are the same as on Pl. II. *Folsomia quadrioculata* has a constancy percentage of 100, and this fact renders it probable that the lower constancy percentage of the species on Pl. II is accidental. *Variatipes quadrangularis* is numerically dominant but only occurs in 2 of the 8 series.

Pergamasus runcatellus and *P. crassipes* are now met with for the first time. They are of common occurrence in the rest of the localities on the Plain.

Pl. IV. 11 series.

Total: 259 individuals = 24 per 1/1000 sq. m.

Dominant	%	Constant	%
Folsomia quadriocul.	20.4	*Folsomia quadriocul.*	91
Tectocepheus velatus	16.3	*Tectocepheus velatus*	81
Chironomidae larvae	8.5	*Peloptulus phaenotus*	55
Influent	**%**	**Accessory**	**%**
Brachychthonius furc.	3.3	*Brachychthonius furc.*	27
Peloptulus phaenotus	3.3	*Isotoma viridis*	36
Scheloribates laevig	2.6	*Scheloribates laevig*	45
Brachychthonius bimacul.	2.3	*Brachychthonius selln.*	27
Tarsonemus species	2.2	*Eupodes berlesei*	36
Tyroglyphus longior		*Tyroglyphus longior*	27
		Tullbergia krausbaueri	27
		Pergamasus runcatellus	27
		Nematodes	27
		Chironomidae larvae	27

While the dominant species on Pl. IV are still *Folsomia quadrioculata* and *Tectocepheus velatus*. the large oribatid species *Peloptulus phaenotus* and *Scheloribates laevigatus* have both become influent. They were found in half of the series.

It is worth noting that *Tullbergia krausbaueri, Variatipes quadrangularis* and

Nanorchestes arboriger were only found in a few specimens. On the other hand, the small *Brachychthonius* species, which are also common in the dry localities, are both influents.

The *Trombidiformes* constitute 14 p. c. in all, that is to say, a small percentage compared with the figures we found for Pls I, II, and III. None of the species need mention.

Pl. V. 8 series.

Total: 205 individuals = 25 per 1/1000 sq. m.

Dominant	%	Constant	%
Tectocepheus velatus	26	*Tectocepheus velatus*	100
Platynothrus peltifer	14	*Platynothrus peltifer*	63
Folsomia quadriocul.	12	*Folsomia quadriocul.*	88
Scheloribates laevig	7.8	*Scheloribates laevig*	75
		Nematodes	62
Influent	**%**	**Accessory**	**%**
Tullbergia krausbaueri	4	*Tullbergia krausbaueri*	50
Zercon suecicus	3	*Zercon suecicus*	
Nematodes	2.5	*Diptera* larvae	38
Enchytraeidae	2.5		
Diptera larvae	2.5		

Folsomia quadrioculata is dominant, and so are *Tectocepheus velatus* and *Platynothrus peltifer.* These species and *Scheloribates laevigatus* are dominant and constant. — There are only two influent species, *Tullbergia krausbaueri* and *Zercon suecicus,* which are both accessory. — Thus the fauna has entirely changed its character, with Pl. IV as the transitional zone, and this becomes apparent inter alias from the fact that the *Oribatidae* now constitute 50 p.c. and the *Trombidiformes* only 9 p.c. of the total amount of animals. — It will be noted that the two dominant oribatid species are relatively large and do not occur in the dry localities. — *Terpnacarus subterraneus, Tarsonemoides belemnitoides* and *Digamasellus angularis* should be mentioned. The latter has been found by FRENZEL in meadows in Silesia.

Only a single specimen of *Malaconothrus globiger* was found.

Pl. VII. 11 series.

Total: 374 individuals = 34 per 1/1000 sp. m.

In the fauna of Pl. VII the *Oribatidae* are likewise dominant, and in this locality *Folsomia quadrioculata* is only an influent species.

Malaconothrus globiger dominates (25 p. c.) but was only found in 5 out of 11 series, a very large number occurring in the sample dating from the 13.

Dominant	%	Constant	%
Malaconothrus globiger	25	*Arctoseius bispinatus*	64
Tectocepheus velatus	17	*Tectocepheus velatus*	91
Scheloribates laevig.	8	*Scheloribates laevig.*	92
		Folsomia quadriocul.	55
Influent	**%**	**Accessory**	**%**
Hypogastrura armata	3	*Hypogastrura armata*	27
Folsomia quadriocul.	3	*Xenylla maritima*	27
Arctoseius bispinatus	3	*Isotoma viridis*	36
Oppia clavipectinata	2.5	— *minor*	27
Enchytraeidae	4	*Tarsonemus spp.*	27
		Brachychthonius selln.	27
		Malaconothrus globiger	45
		Oppia clavipectinata	36
		Enchytraeidae	36
		Chironomidae larvae	36

October 1942. Altogether the species seems to occur in colonies. TUXEN (1943 cp. table IV) at any rate found this to be the case in his samples from Iceland. — As already stated, only one specimen was found on Pl. V, whereas its constancy percentage on Pl. VII is 45. *Malaconothrus globiger* may therefore be regarded as a characteristic species on Pl. VII. As on Pl. V, *Tectocepheus velatus* and *Scheloribates laevigatus* are dominant and constant.

Hypogastrura armata, Arctoseius bispinatus and *Oppia clavipectinata* are influent, *Arctoseius* being constant, the others accessory.

The *Oribatidae* constitute 55 p. c. on Pl. VII, while the proportion of the *Trombidiformes* in the total fauna is only 7 p. c., that of the *Gamasidae* being still 9; the *Collembola* only constitute 12 p. c.

Pergamasus runcatellus and *Arctoseius bispinatus* together make up 5 p.c. of the fauna. — *Proisotoma minima* and *Isotoma notabilis* were found in this locality but only in few specimens.

SURVEY OF THE OCCURRENCE OF THE CHIEF SPECIES

In the pages that follow the dominant species will be briefly surveyed. They are arranged according to their occurrence, beginning with the animals characteristic of the high-lying localities and ending with those typical of the low-lying localities.

Folsomia quadrioculata is dominant in all localities except on Pl. VII. In the dry part of the sampling line its relative frequency is 20, whereas it is 12 and 3 p.c. respectively on Pls V and VII. — This is in good agreement with HAMMER'S results (1937, pg. 29). She found that the species was most nu-

merous in the dry biotopes, thus it was entirely dominant on the Lichen heaths (cp. p. 180). GISIN says (1943) that the animal is the most common collembole in the upper layers of the soil. As previously mentioned, AGRELL found that the resistance of the species to desiccation was comparatively slight, and by cultivation experiments I have convinced myself that this is the case with individuals from the localities on the Plain too. The animals were extremely delicate and even a quite brief drying of the cage resulted in death. It is uncertain how they survive the warm and dry period.

Tectocepheus velatus dominates in all localities except on Pl. I. The animal was found everywhere in the grounds of the laboratory, but is was most numerous in the raw humus on Pl. B and on Revlinghøj. The species is termed an ubiquist and is mentioned in every work dealing with the microfauna of the soil. WILLMANN (1942, pg. 168) states that it is a characteristic form of the high moor, while TUXEN (1943, pg. 322) found that it was a dominant on the dry »mèlar« among the vegetation, while it was absent from the »floi«. — Thus the information is scattered, and the ecological requirements of the species are very little known.

Variatipes quadrangularis dominates on Pls I, II, and III. On Pl. III it was only found in 2 out of 8 samples. On Pls IV-VII it was found in some few specimens. — The animal seems to be of common occurrence in the soil; thus it has been met with in the meadow samples and on Pl. C; in other words, this means that the species also occurs in constantly moist localities. In the Southern Meadow it is found in company with *Platynothrus peltifer* and *Malaconothrus globiger*. — FRENZEL found it in a meadow in Silesia and it is known from rotting parts of plants and old manure (PAOLI 1911, pg. 230). Otherwise no information of this animal is available.

Nanorchestes arboriger was found in all localities of the Plain, and everywhere throughout the terrain. It is only dominant on Pl. I where it is also constant. On Pl. II it is an influent and in the other localities only a few specimens were taken. On Revlinghøj and the humid Rogeshøj it is found in raw humus and moss, and so it does noot seem to be adapted to any particular moisture conditions. — THOR (1941) states that the species is common in moss in Norway. — It is doubtful whether this species is *Nanorchestes arboriger* BERLESE 1905, but the reader is referred to the Appendix.

Tullbergia krausbaueri dominates and is constant on Pls I and II but has further been found regularly in all the localities. It was also found in the Meadow and the Southern Meadow, but not in moss and raw humus. — The species is frequent in almost any soil (GISIN 1943).

Scheloribates laevigatus. This large species is first met with on Pl. IV, where it is an influent, while on Pls V and VII it is dominating and constant. Further

it is found on Pl. C, the Meadow, the Southern Meadow and in a winter sample from the middle, dry part of the Plain. On Revlinghøj and Rogeshøj it was replaced by *Sch. pallidulus*. — FRENZEL (1936, pg. 94) terms *Sch. laevigatus* a leading form of the meadow, and WILLMANN (1942, pg. 168) states that it is typical of bogs, but also frequent in moss and humus (1931, pg. 160). SELLNICK (1940, pg. 39) found it both in moist and fairly dry localities but most common in the moist ones.

Platynothrus peltifer was only found on Pls V and VII. It is dominating and constant on Pl. V, while it is scarce on Pl. VII. The species is found in numerous specimens in the Southern Meadow, in the upper layer and is, in additon, characteristic in samples from the moist part of the Plain during the thaw of 1942 (Pl. samples 6-8 and sample 14). — FRENZEL (1936, pg. 94) calls it a leading form of meadows; WILLMANN (1942, pg. 168) regards it as a characteristic form of high moor. Altogether the species has only been reported from moist or very moist localities where it is common in most places. HAMMER (1934, pg. 33 and 1937, pg. 32) characterises the moist soil community by means of this very species. TUXEN (1943, pg. 333) found that *Pl. peltifer* dominated in the tufts of the »myri« and partly in the »floi«, which are flooded large parts of the year. MICHAEL (1884, pg. 465) states that the nymph is amphibious.

Malaconothrus globiger. The species is difficult to distinguish from *M. egregius*, and the two animals have the same occurrence. As previously stated, it is characteristic of Pl. VII and has also been found in the Southern Meadow. It has only been recorded from very moist localities, and WILLMANN (1942, pg. 167) calls it a character animal of the high moor. FRENZEL (1936, pg. 95 and 97) frequently found *M. egregius* in meadows; but it was only dominating in a very moist *Cyperaceae* meadow at Nippern.

Not only the chief species have a characteristic distribution in the localities of the Plain; but many of the numerically less significant species only occur in some few parts of the sampling line, and these species will now be discussed. The animals are mentioned systematically.

The *Collembola. Isotomodes productus* is known from dry localities, (GISIN 1943). Two specimens were found only (Pl. I.).

Isotoma viridis was found everywhere both in juvenile and adult stages. It was observed several times that the adults jumped out of the samples and thus escaped when these were placed in the sieves. The halfgrown individuals frequently occur in the upper layer and newly hatched individuals even in the layer 1-2 cm. — *Isotoma viridis* occurs on the Plain in 2 colour forms, *f. pallida* and *f. coerulea*. The former is found both in the dry and in the moist part of the Plain; the dark *f. coerulea*, on the other hand, inhabits ex-

clusively the moist localities. AGRELL (1941, pg. 117) observed similar conditions in Lapland, and experiments further proved that the light-coloured form showed a much greater resistancy to desiccation than the dark one. On the 14th of May 1948 in the morning I observed many large individuals in all the localities of the Plain, and the great difference in colour between the animals in the higher and in the lower part of the Plain was conspicuous. It is thus characteristic that the differences in moisture of the short sampling line are plainly reflected in the colour forms of these large freely moving animals.

Proisotoma minima. The species is characteristic of moist soils (GISIN 1943) and was indeed only found on Pl. VII and in the deeper layers of the Meadow

The *Gamasidae* occur most frequently in the moist and moderately moist localities; but some few species were especially found on Pls I and II.

Digamasellus No. 4 only occurred on Pls I and II and in a qualitative sample from the dry part of the Plain.

The same applies to the species *Vitzthumia magniscutum* and *Asca nova* (WILLMANN 1939). — FORD (1938, pg. 353) found that *Asca aphidiodes* (KRAMER) with *Hypochthoniella pallidula* and *Pseudachorutes subcrassus* were dominants in tufts of *Bromus erectus.* This habitat is frequently exposed to desiccation and the two latter species are also known from bark and other dry localities. If FORD's species is really KRAMER's *Asca aphidioides,* the two *Asca* species so far known occur in typically dry habitats.

Arctoseius bispinatus was found in all the localities but like *Pergamasus runcatellus* and *P. crassipes* it is most frequent in the low-lying ones. Thus the two latter species have not been found above Pl. III.

Zercon suecicus is only recorded from Pls V and VII. *Z. suecicus* has only been found by FORSSLUND on a single locality in northern Sweden (FORSSLUND 1943) where it is a characteristic and dominating species in the deeper layers of the soil. The description shows that this soil on essential points resembles that of Pl. V-VII.

The *Trombidiformes* are by far most numerous in the dry localities.

On the Plain *Coccotydeus frequens* was only observed on Pls I, II, and III, but was also found in the samples from the Meadow, from Rogeshøj, and from Revlinghøj. The varying appearance of the species in these localities is mentioned in the Appendix.

Tydeus hyacinthi and *T. tridactylus* occurred in many localities, but these as well as the rest of the *Prostigmata* were found in so few specimens that a more detailed account of their distribution is not possible on the basis of this material.

The *Oribatidae* dominate entirely in the moist localities. — The genus *Bra-*

chychthonius deserves special mention. Several species of this genus are said to be character animals of *Sahagnum* bogs (WILLMANN 1942, pg. 167). In the localities of the Plain only *Br. sellnicki* is of common occurrence throughout the sampling line, while *Br. furcatus* and *Br. bimaculatus* have been found exclusively in the dry part of the Plain. *Br. berlesei,* which WILLMANN regards as a character animal of bogs, was especially found on Pls I and II (some few specimens on Pl. VII). In other words, the moisture of the soil does not seem to be of decisive importance for the occurrence of these species; but it is probable that other factors (e. g. food) play a prominent role.

The *Oppia* species were found dispersed everywhere. The species observed were *O. clavipectinata* and *O. minus.*

Scutovertex minutus was only found in the high part of the Plain and is known from thatch-moss and other dry and warm localities. It has been found by NØRGAARD on a nest of *Theridium saxatile* in full sunshine (ca. 40° C).

SUMMARY OF THE FAUNA IN THE LOCALITIES OF THE PLAIN

As previously mentioned, it is seen that the share of the *Collembola, Trombidiformes* and *Oribatidae* varies gradually as we pass from one end of the line to the other. This shows the existence of ecological differences between the individual systematic groups, whether these differences refer to moisture requirements, food, size or the like. This does not mean, however, that one group is found exclusively in dry localities, but the facts show that with some caution and with due consideration of the exceptions, the systematic groups may be regarded as large ecological units, in the same way as e. g. hoofed animals may be regarded as steppe animals and monkeys as forest animals, and the anatomical differences between the *Trombidiformes* and the *Oribatidae* are in fact much greater than between these two orders of mammals. This of course does not prevent one oribatid and one trombidiform from requiring the same habitat, while conversely nearly related species may be found in quite different localities, just as the okapi occurs in dense forests while its nearest recent relative the giraffe, is a typical savannah animal.

While thus the proportion of the individual groups varies in the different localities, this is not less true of the individual species, as it appears from our survey of the fauna of the individual localities. And the same conditions are shown below.

All the dominant species in the 6 localities are mentioned below with their frequency percentage.

		Frequency percentage
Pl. I:	*Folsomia*	25
	Variatipes	9
	Tullbergia	8
	Chironomidae larvae	6
	Nanorchestes	5
Pl. II:	*Folsomia*	21
	Tectocepheus	17
	Tullbergia	11
	Variatipes	5
Pl. III:	*Tectocepheus*	20
	Folsomia	14
	Variatipes	8
Pl. IV:	*Folsomia*	20
	Tectocepheus	16
	Chironomidae larvae	8
Pl. V:	*Tectocepheus*	26
	Platynothrus	14
	Folsomia	12
	Scheloribates	8
Pl. VII:	*Malaconothrus*	25
	Tectocepheus	17
	Scheloribates	8

While certain species dominate almost in all localities others are only met with in large numbers in a few. Thus it is seen that *Folsomia quadrioculata* and *Variatipes quadrangularis* both dominate on Pls I-III, while *Tectocepheus velatus* and *Scheloribates laevigatus* are both dominant on Pls V and VII. The fauna of the individual localities may be characterised by means of one of these combinations plus one or two species dominant in and characteristic of of the said locality. This fact appears plainly in the table below, which comprises all dominant and at the same time constant species.

Species characteristic of the individual localities.

Dry part:

Folsomia quadr. 25-20 p.c. and *Variatipes quadrang.* 9-5 p.c.	Pl. I: *Tullbergia* (8 p.c.) — *Nanorchestes* (5 p.c.) Pl. II: *Tectocepheus* (17 p.c.) — *Tullbergia* (11 p.c.) Pl. III: *Tectocepheus* (20 p.c.).
Pl. IV: The transitional fauna	*Folsomia* (20 p.c.), *Tectocepheus* (16 p.c.) plus species characteristic both of high and low-lying localities

Moist part:

Tectocepheus velatus 17-26 p.c. } Pl. V: *Platynothrus* (14. p.c.) — *Folsomia* (12 p.c.)
Scheloribates laevigatus 8 p.c. } Pl. VII: *Malaconothrus* (25 p.c.)

Two animal communities[1]) may be distinguished on the Plain, a *Folsomia-Variatipes* community on Pls I-III, which through the fauna of Pl. IV is connected by gradual transitions with a *Tectocepheus-Scheloribates* community. It applies to the two communities that the fauna varies gradually with the situation of the individual localities.

The best idea of the appearance of the fauna in the three main localities Pls I, IV, and VII can be gained by considering Fig. 31, where the average numbers of dominating or characteristic species per series from each locality are shown. Here the great difference is seen between the faunas of the localities in question, and the few points of resemblance between the fauna of Pl. I and that of Pl. VII, both concerning the species and their sizes, are especially striking. Further, it will be noted that the fauna of Pl. IV which, as previously shown, is a transitional zone between the part of the Plain dependent on the ground water and that independent of it, must also, faunistically, be regarded as a transitonal locality.

In other words, in spite of the small amount of numerical material it can be established that the successive changes in water content, the vegetation, and the ecological factors connected with these, are attended by successive changes in the specific composition of the fauna. But at the same time, as in the case of the flora, we find a line of demarcation between the faunas of the high-lying and the low-lying localities. These facts show that the microscopical arthropod fauna, too, responds readily to changes in the external conditions, and that the fauna has not the accidental character which might appear from collection of a large number of samples from many different, not very well characterised localities (cp. HAMMER 1944, pg. 74). — Wherever the same complex of environmental conditions occurs in nature the same microfauna may be expected. — At the same time the distinct difference between the faunas of the moist and the dry part of the Plain suggests that the water content is of great importance for the distribution of the animals in nature, whether the water must be regarded as the direct or the indirect distributive factor (see discussion).

The following remarks in connection with the Figs. 15-17 and 31 may serve as a further characterisation of the two animal communities.

The *Folsomia-Variatipes* community is composed of relatively small spe-

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[1]) The author's use of the term community, see pg. 145.

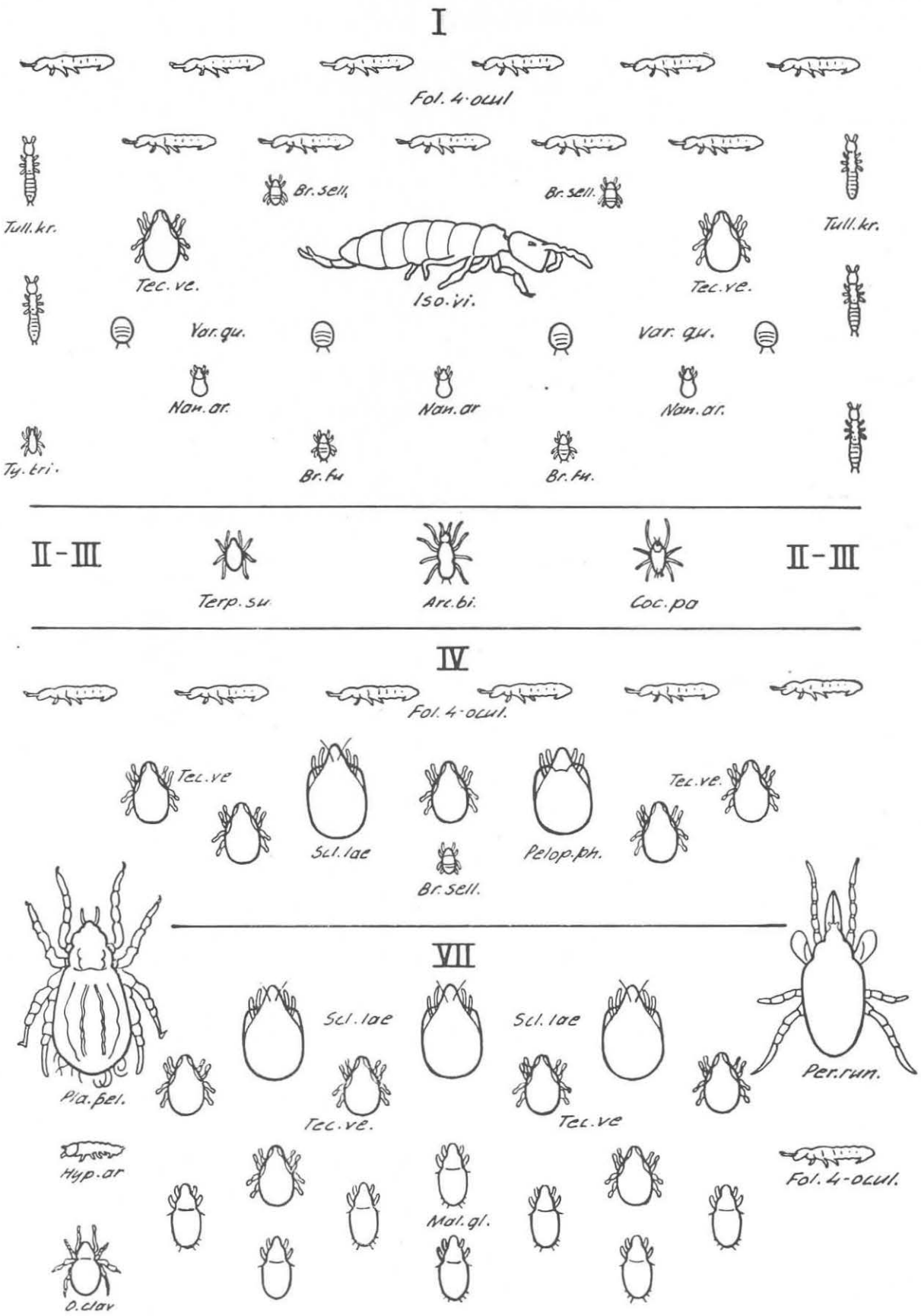

Fig. 31. The fauna in Pls. I, IV, and VII.
Average numbers of dominant and characteristic species.

cies, and the proportion of *Trombidiformes* and *Collembola* in the total fauna is very large.

The characteristic species of the *Tectocepheus-Scheloribates* community, on the other hand, are large or medium-sized *Oribatidae*, and the *Trombidiformes* and the *Collembola* are in the minority.

The fauna of Pl. IV forms a transition between the two communities; *Tectocepheus velatus* and *Folsomia quadrioculata* are dominating, *Brachychthonius furcatus, Br. bimaculatus*, and *Tarsonemus* species are frequent. But *Scheloribates laevigatus*, which was not found in the higher localities, is an influent species here and was found in 45 p. c. of the samples.

It would be tempting to say that the species characteristic of the dry animal community on the Plain were xerophilous, while the species characteristic of Pls V and VII were hygrophilous or the like, and in that case one might, like HAMMER (1934, 37 and 44), call the *Folsomia-Variatipes* community a dry-soil community and the *Tectocepheus-Scheloribates* community a moist-soil community. But this division cannot be made, even though conditions on the Plain do not seem to militate against it. Many of the very species which are characteristic of the dry localities are frequently, as mentioned in the survey, found in great numbers in moist localities. *Tectocepheus velatus* is also frequently found in dry localities if other conditions permit, whereas species such as *Platynothrus peltifer, Malaconothrus globiger, Proisotoma minima*, and others have so far only been found in moist localities, bogs, meadows, moist forest soil, and the like. Generally speaking one cannot call the two above-mentioned communities a dry-soil and a moist-soil community respectively: in that case excessive importance is attached to the water content at the sacrifice of the other factors which may affect the composition of the fauna, e. g. food, structure, and so forth. At most one may talk of the dry-soil and moist-soil communities of the Plain, as the entire history and the present conditions of the Plain show that the moisture conditions have directly, and no doubt just as much indirectly, decisively affected both the flora and the fauna.

THE NUMBER OF INDIVIDUALS AND THE VERTICAL DISTRIBUTION OF THE FAUNA

Table 19 shows:

1. The total number of individuals in the various localities.
2. The average number of individuals per series: The average number of individuals per 1/1000 sq.m of surface.
3. The total and relative number of individuals in the different layers.
4. The average number of individuals per sample.

	Number of series: 1/1000 sq.m.	Total number of individuals	Average number of individuals per series: 1/1000 sq.m.	Depth 0—1 cm			Depth 1—2 cm			Depth 2—3 cm			Depth 3—4 cm			Depth 4—5 cm			Average number in the layers 1-5 cm	Total number in the layers 1-5 cm	Per cent of the total fauna
				Total number	Per cent of total fauna	Average number per sample	Total number	Per cent of total fauna	Average number per sample	Total number	Per cent of total fauna	Average number per sample	Total number	per cent of total fauna	Average number per sample	Total number	Per cent of total fauna	Average number per sample			
Pl. I	10	483	48	334	**69**	33	58	**12**	6	26	**5,4**	2-3	34	**7,0**	3-4	32	**6,9**	3	15	146	31
Pl. II	8	363	45	287	**79,7**	36	28	**7,7**	4-5	27	**7,5**	4-5	17	**4,7**	2	4	**1,1**	0-1	9-10	76	21
Pl. III	8	166	21	128	**77**	16	20	**12**	2-3	3	**1,8**	0-1	7	**4,2**	1	8	**4,8**	1	4-5	38	23
Pl. IV	10	259	26	148	**57**	15	52	**20**	5	29	**11**	3	19	**7,3**	2	11	**4,2**	1	11	111	43
Pl. V	8	205	26	166	**81**	21	16	**8**	2	4	**2**	0-1	8	**4**	1	11	**5**	1,2	5	39	19
Pl. VII	10	332	33	235	**71**	24	53	**16**	5	9	**2,7**	1	27	**8**	3	8	**2,4**	1	10	97	29

Table 19

The average number of animals per unit of area is greatest on Pls. I, II and VII, whereas the number in the grass vegetation is considerably lower. In the first localities plants with a horizontal form of growth are dominant, while grass has a vertical growth form. The definite figures are low, but are in fairly good agreement with the values which FRENZEL (1936) and HAMMER (1937) found in similar localities. The average number of animals per 1/1000 sq.m ranges from 20 to 50.

It will be seen that 70 p.c. of the animals inhabit the uppermost layer, while the number decreases rapidly as we pass downwards. In other words, the microfauna on the Plain is concentrated in the uppermost centimetre of the soil. — In the meadow and in the raw humus on Rogeshøj, on the other hand, animal life in the deeper layers is considerably more abundant, as will be shown later.

The species met with in the deeper layers are partly such species as occur chiefly in the surface layer (0-1 cm), and partly species of which a considerable number was found in the layer 1-5 cm. The latter species are said to occur subterraneously on the Plain.

I the subjoined table 20 all species have been included which were found in the layers 1-5 cm in the locality in question. The total number of individuals at 0-1 and 1-5 cm has been calculated.

As will appear from the tables, the following species occur subterraneously on the Plain.

		Number 0-1 cm	Number 1-5 cm
Collembola:	*Tullbergia krausbaueri*	60	45
	Hypogastrura armata	14	13
Gamasidae:	*Zercon suecicus*	3	6
Trombidiformes:	*Variatipes quadrangularis*	24	55
	Nanorchestes arboriger	8	19
	Terpnacarus subterraneus	4	10
	Coccotydeus frequens	4	7
Oribatidae:	*Brachychthonius bimaculatus*	5	4
	— *furcatus*	8	8
	Malaconothrus globiger	51	35
Acaridiae:	*Calvolia* deutonymph	1	16
Mixed:	*Chironomid* larvae	47	29

Collembola. Tullbergia krausbaueri. FRENZEL (1936, pg. 72) found that this species in company with *Tullbergia quadrispina* was almost sole prevailing in the deeper layers of the soil in the meadows of Silesia, and GISIN (1943) calls it a typical euedaphic animal. On the Plain *Tullbergia krausbaueri* was frequently found, both in the surface layer and in the layers below, particularly in the dry part.

	Pl. I		Pl. II		Pl. III		Pl. IV		Pl. V		Pl VII	
	Average number in the layers		Average number in the layers		Average number in the layers		Average number in the layers		Average number in the layers		Average number in the layers	
	0-1 cm	1-5 cm	0-1 cm	1-5 cm	0-1 cm	1-5 cm	0-1 cm	1-5 cm	0-1 cm	1-5 cm	0-1 cm	1-5 cm
Hypogastrura armata			5	3	1	2	1	1	1	1	6	6
Xenylla maritima								1				
Tullbergia krausbaueri	32	18	24	15				2	4	4		6
Isotomodes productus	1	1										
Folsomia quadrioculata	116	11			23	1	38	17			7	3
Proisotoma minima											2	2
Isotoma viridis					4	3						
Isotoma violacea		1										
Lepidocyrtus cyaneus				1								1
Sminthurinus aureus		1										
Asca nova			2	1								
Arctoseius bispinatus	5	1	4	1	4	3			(1)		9	1
Lasioseius								1				
Hypoaspis sp.												1
Lælaptid II		1								1	1	1
Lælaptid V												1
Zercon suecicus									3	3	1	3
Variatipes quadrangularis	8	38	7	10	8	5	1	1				1
Pygmephorus spp.		1				2					1	
Tarsonemus sp			1	3		1			2	1		1
Tarsonemoides brevilobus						4	1	2		3		
Alicorhagia fragilis				1						1		
Terpnacarus subterraneus			1	7		2			3	1		
Nanorchestes arboriger	6	15	(8)		(1)		2	1		2		1
Rhagidia mordax		1										
Tydeus hyachinti	1	1						4		1		
Tydeus tridactylus				2								
Coccotydeus frequens	2	6		1	2	1						
Triophtydeus pinicolus		1										
Microtydeus fenilis	4	1				1						1
Lorryia reticulata		1				1				1		
Ereynetidae								1				1
Eupodes berlesei	4	1						2				2
Bryobia praetiosa	4	1										
Cheyletus eruditus								1				
Bdella lignicola		1										
Bdella larvae		2										
Brachychthonius sellnicki	14	2	13		(4)						5	1
Brachychthonius bimaculatus	1	2					4	2				
Brachychthonius furcatus	3	4		8		1	4	5				
Platynothrus peltifer			( )						28	1		
Malaconothrus globiger											51	35
Oppia clavipectinata			4	5				1		1		
Oppia minus	1	2						2				
Oppia sp				2								
Tectocepheus velatus	20	2			33	2	32	13	50	2	44	2
Trichoribates trimaculatus		2						1				1
Scheloribates laevigatus									15	1		
Oribatid nymph								1				
Tyroglyphus longior						1	1	6				
Swiebia talpa											3	2
Calvolia deutonymphs	1	5						2				9
Cerophagus								1				
Diptera larvae	25	7	5	1	(7)		3	20	7	4		
Staphylinidae	2	3										
Various	6	8	3	5	2	7	4	18		2	7	11
	256	141	56(77)	66	77(89)	37	91	106	113	30	137	93

Table 20

Hypogastrura armata, according to GISIN, should occur where there are many remains of plants. The species has been found in caves (PAX and MASCHKE 1935). It was present in all localities of the Plain, but was most frequent on Pl. VII. It occurs mainly in the two uppermost centimetres.

Gamasidae. Zercon suecicus. All *Zercon* species are slow animals, and in their movements and structure the differ very much from the large *Parasitidae*, which mostly live at the surface. FORSSLUND (1943) found that *Zercon radiatus* was more common in the mould and humus layer than in »Ytskikten« (= the surface layer), and he often found the greatest number of individuals in the dense humus layer and the same applies to *Z. suecicus* on a single locality (see P. 84). It is probable, therefore, that the *Zercon* species are usually denizens of the deeper layers. In cages I have observed that they attacked cheese mite larvae; but it is quite possible that their chief nourishment consists of nematodes. The species was found on Pls. V and VII in the deeper layers.

Rhodacarus roseus occured in the *Calluna* locality, Revlinghøj and Rogeshøj. The *Rhodacaridae* are known even from great depths (FRENZEL 1936, pg. 107).

Trombidiformes. Variatipes quadrangularis. In this connection it need merely be mentioned that in 1936 FRENZEL besides this species also found other *Scutacaridae* (*Imparipes* and *Scutacarus* species) in the deeper layers. The table shows that the species was chiefly met with below the surface layer and it is thus characteristic of the deeper layers in the dry part of the Plain.

The mouth parts of the *Scutacaridae* are very small, pointed, and provided with quite insignificant maxillary palpae; thus they recall the mouth parts of the rest of the *Tarsonemini* in every respect. It would therefore seem natural to assume that the *Scutacaridae* are root-suckers, as the *Tarsonemini* usually suck juice from living plants (REUTER 1909, VITZTHUM 1943, pg. 669).

Nanorchestes arboriger. The animal has distinct eyes and is able to jump; thus in its morphology it is not a typical soil animal, and in fact. as already mentioned, it is common in moss. On the plain it was chiefly found in the deeper layers and its subterranean occurrence shows that it is not exclusively a denizen of the surface.

The same applies to *Terpnacarus subterraneus.* GRANDJEAN (1939) states that T. BOUVIERI (GRA. 1939, pg. 51) is xerophilous and was found moving freely on the surface.

Coccotydeus frequens. GRANDJEAN (1938) states that the species is common in moss. It was found in the meadow and in moss and raw humus on Rogeshøj and Revlinghøj. On Pls. I, II and III the species occurred in the deeper layers.

The *Prostigmata* are on the whole often found in the deeper layers of the Plain, but occur in the greatest number in moss. FRENZEL (1936, pg. 96) states

that animals of this group are frequently seen below the surface layer (e. g. *Retetydeus* sp.). *Tydeidae* and *Eupodidae* are usually small brisk animals with eyes, and thus seem to be adapted to surface conditions; but *Tydeus hyacinthi* and *T. tridactylus* often occur at a depth of 1-5 cm. Unlike the *Tydeidae* in general the *Retetydeus* group (*Lorryia reticulata* and *Raphignathus raphignathoides*) are, however, clumsily built animals without organs of sight, and in fact they regularly occur in the deeper layers.

Oribatidae. *Brachychthonius bimaculatus* and *Br. furcatus*. *Br. bimaculatus* was found by FRENZEL in 1936 in some few specimens. — This species as well as *Br. furcatus* frequently occured in the deeper layers in the dry part of the Plain, thus it was abundant in the layers 2-8 cm in a couple of supplementary samples (Pl. samples 1 and 2). On the other hand, only some few individuals were found at the surface. The samples from Rogeshøj show that the *Brachychthonius* species occur both in moss and raw humus; but the species are different in the different layers. On the Plain conditions were similar, *Br. sellnicki* and *Br. berlesei* being denizens of the surface in contrast with the two above mentioned species.

Oppia clavipectinata and *O. minus* as well as the *Suctobelba* species were often found at fairly great depths, thus in samples from the thaw in 1942 from the moist part of the Plain (Pl. samples 10-13) and in samples of humus from Rogeshøj.

Other species.

Calvolia deutonymphs were found in some few specimens in the deeper layers on Pl. VII.

Chironomid larvae. Only the samples from Pl. IV (20. Nov. 1943) contained a large number of animals in the lower layers.

Summary.

The species which are frequently met with subterraneously are *Variatipes quadrangularis*, *Tullbergia krausbaueri*, *Nanorchestes arboriger*, *Brachychthonius bimaculatus*, and *Br. furcatus*. — As will be easily seen these are the very species which are characteristic of the dry soil communities of the Plain, while they are very seldom met with on Pls. V and VII. The rather large number of animals in the layer 1-2 cm on Pl. VII consists mainly of *Malaconothrus globiger*, the number of which, however, is highest in the surface layer and decreases rapidly downwards.

The difference between the two communities erected appears plainly in the composition of the subterranean fauna too.

The numerical material is too small for detailed conclusions, but I may point out that the fauna in the deeper layers on Pls. V and VII is poorer than in the dry localities.

In Figs. 15, 16 and 17, showing magnifications of soils from Pls. I, IV, and VII, the principal animals at the different depths in the three localities have been drawn at the same magnification. — The structure and size of the microcaverns have previosly been mentioned. We shall here point out that all the typical subterranean arthropod species from the Plain are small, and that the larger species which dominate at the surface are unable to move in the deeper layers simply because of their size. It should be noted, however, that *Folsomia quadrioculata* even in the adult stage is so small that its absence from the deeper layers cannot be wholly due to the lack of space, but must be caused by other factors (e. g. food, light, etc.). The same applies to nymphs of *Tectocepheus velatus* and several others.

ANNUAL VARIATIONS OF THE FAUNA

The number of individuals in the various series at the different periods may be seen in the table below. At the foot of the column the total number of individuals is stated.

Loc. \ Date	$^{19}/_{7}$ 42	$^{13}/_{10}$ 42	$^{19}/_{11}$ 42	$^{12}/_{1}$ 43	$^{7}/_{3}$ 43	$^{11}/_{4}$ 43	$^{15}/_{5}$ 43	$^{17}/_{6}$ 43	$^{18}/_{8}$ 43	$^{7}/_{11}$ 43
Pl. I	a: 42 b: 48	159	9	81	44	35	55	3	19	35
Pl. II		132		41	57	21	30	38	22	36
Pl. III		22		19	17	22	26	9	14	38
Pl. IV	80	28	16	14	9	6	19	15	13	66
Pl. V		42		17	10	7	32	3	28	68
Pl. VII	a: 61 b: 42	139	27	18	31	9	7	1	10	29
	a: 183 b: 170	522	52	190	168	100	169	69	106	272

Table 21

Similarly as in the results arrived at by FRENZEL (1936, pg. 34-38), FORD (1938, pg. 365), and BAJEVA (1939, pg. 145), the fauna on the Plain is subject to great quantitative fluctuations, which are manifested in an autumn maximum and a summer minimum, whereas no spring maximum has been noted.

The largest number of individuals was found in October 1942 (522 specimens from the 6 localities, 159 of which were derived from Pl. I). In 1943 no samples were taken in that month, but the samples from November show that animal life in the autumn months is considerably richer than in the spring and summer. April, Maj, (June), July, and August have previously been termed the critical months in respect of moisture. Animal life during this period is indeed very poor in all the localities. Unfortunately no samples were taken from the very driest period at the close of July and the beginning of August.

We thus note the remarkable fact that animal life has its maximum in the moist period and its minimum in the dry period, so there would seem to be a close connection between the changes in the water content and the variations in the quantitative occurrence of the animals.

It will appear from the table that animal life in that part of the Plain which is dependent on the ground water is subject to at least just as great variations as the fauna of the dry part, and this shows that the water content and the relative moisture cannot in themselves be regarded as the only restricting factors. This is rendered still more obvious, inter alia by the fact that in 1942 animal life attained its maximum in October. An accident to the Berlese apparatus in November 1942 was no doubt the reason why the samples contained so few animals. Fig. 13 shows, however, that in September and October the rainfall was very slight, and the ground water level in October was the same as in August. From Figs. 22-34 it will appear that the water percentage in layers 1-5 cm in all the localities ranged around or even fell below the annual mean. Only on Pl. I did the water percentage in the upper layer rise considerably above the mean value, while on Pls. IV and VII it kept just around the annual mean. Thus the absolute water content at the period when animal life attained its maximum was not very large, and the water content in the spring of 1943 was in several localities almost the same as in October the year before. However, the air in the pores of the earth was everywhere saturated with water vapour. Other soil organisms also, among them *protozoa* and *bacteria* (CUTLER, CRUMP, and SANDON 1923, pg. 322), have a maximum in the autumn months. In addition, *protozoa* and *bacteria* attain a relative maximum in the months of spring and a minimum in February and June. According to these authors, the minimum in February is due to the cold, whereas the drought in June-July is said to be the cause of the summer minimum. The maximum in the spring and autumn is stated, inter alia, to be due to the high water content. The importance of a constant, but not excessive moisture*), the optimal water content, for the growth of the microorganisms of

*) KOLLMANNSPERGER (1934) and THOMSON (1924) point out how important it is that the soi should not be supersaturated with water.

the soil is pointed out by WAKSMAN (1930); but he also emphasises that the addition of organic remains results in a great rise in the fungal and bacterial flora. The food of the Oribatids consists in great part of fungal hyphae (FORSSLUND 1938 and 43). It is most probable therefore that the abundance of individuals of the arthropod microfauna in the autum months must be viewed in connection not only with the constant and suitable degree of moisture below and on the surface of the soil, but also with the abundant supply of nourishment due, inter alia, to the many dead parts of plants after the vegetation period.

In order to understand the quantitative variations of animal life it is not enough, however, to consider the external factors which may be conceived to be of importance, but it is also necessary to investigate the breeding periods and developmental conditions of the individual species. Only for the *Oribatidae* and the *Collembola* (MICHAEL 1883-87, HAMMER 1937) have we any detailed information of this. Some collemboles have only one annual generation, while others apparently have several. As far as we know, the *Oribatidae* have only one annual generation, but it applies to both groups that sexually mature and newly hatched animals occur at all seasons. The great fluctuations in the number of individuals would seem to show, therefore, that the environmental factors are of considerable significance for the breeding periods, even though the breeding times of the individuals may be determined by »internal« factors.

The qualitative composition of the fauna does not change in the course of the year, apart from the fact that *Bryobia praetiosa* was only found in the spring and summer samples. This accords well with the fact that the species, like the rest of the *Tetranychidae*, hibernates as eggs.

As previously stated, mites and collemboles are generally found both as adults and as young ones. On the other hand, the ratio between the numerical proportion of the old and the young individuals seems to alter in the course of the year; but the number of specimens is too small to give a more detailed account of the conditions. The following observations may be mentioned.

Folsomia quadrioculata. The species has been found in the juvenile stage (less than 40 p. c. of the maximum length, AGRELL 1941, pg. 137) at all seasons. As a rule there are about twice as many adults as young ones. The greatest number of individuals occurred in October and March; with special frequency in the October samples from Pls. I and II. Hibernates in all stages.

Tectocepheus velatus. Adults and juvenile stages were usually found in equal numbers. In the localities of the Plain the number of protonymphs seems to decrease in the course of the early summer. The species winters in all stages

Thus in Pl. sample 3 from Jan. 16. 1942 there occured 8 adults, 22 larvae, and 16 nymphs, 4 of which were protonymphs, while the rest were deuto- or tritonymphs.

Scheloribates laevigatus. Nymphs and larvae were especially found in late summer, autumn, and winter. Thus a sample from the thawing period in 1942 contained a total of 34 individuals, none of which were adult, 4 being larvae and 30 nymphs.

Platynothrus peltifer. Larvae and nymphs were found in the autumn and winter. On April 3. 1942 Pl. samples 6-8 and sample 14 thus contained in all 4 adults, 3 larvae, 5 protonymphs, and 5 deuto- and tritonymphs.

Malaconothrus globiger. Larvae and nymphs occured in March, June, October, and November. In October 1942, for instance, there occurred 10 adults, 11 larvae, 13 proto-, 12 deuto-, and 16 tritonymphs.

No detailed information is at hand about the *Trombidiformes*; but it may be mentioned that in a sample from Jan. 6. 1942 (Pl. sample 3) there were 30 *Tydeus tridactylus*, of which only 4 were adult, the rest being nymphs.

In general it may be said that the principal breeding period is in the late summer and the autumn, but the *Gamasidae* seem especially to breed in spring and early summer, at which period females with eggs and protonymphs were found (e. g. *Pergamasus runcatellus, P. crassipes,* and *Arctoseius bispinatus).*

SUPPLEMENTARY SAMPLES

THE PLAIN. (Table 15).

On Jan. 16. 1942 supplementary samples were taken from the frozen ground in the dry part of the Plain. (Pl. samples 1-3). The earth was frozen to more than 10 cm.

As will be seen from samples 1 and 2, animal life in the deeper layers is dominated by *Brachychthonius furcatus* and *Br. bimaculatus*, while only some few *Variatipes quadrangularis* occur. This species, however, is usually uncommon in the winter samples. As will be noted, the facts are in good agreement with the results from the sampling line.

Pl. sample 3 was taken from the frozen grass and moss. *Tectocepheus velatus* and *Tydeus tridactylus* are dominants. The latter species was only found sparsely on the sampling line. Perhaps this was due to the lack of moss cushions. At any rate it is characteristic that moss samples from Rogeshøj and Revlinghøj contain relatively more *Tydeidae* than the corresponding samples from raw humus. *Folsomia quadrioculata* only occurs sparsely, which may be due to the relatively large number of *Gamasidae*. The characteristic *Gamasidae* from Plains IV, V, and VII did not occur. *Scheloribates laevigatus*

and *Scutovertex minutus* were found in 4 specimens and 1 specimen respectively, whereas neither *Platynothrus* nor *Malaconothrus* were present.

It will appear from the above and from the table that neither the subterranean nor the surface fauna deviate essentially from the conditions found in the dry part of the sampling line of the plain.

3.4.-42. Pl. samples 6-11 and 14-17 (Table 15) 1/1000 sq. m. 0-18 cm.

The first samples were taken from a low bank nearly resembling Pl. IV. It was not flooded and the upper 10 cm had thawed; below, the earth was frozen. The second series of samples derives from a locality about 1 m from the first. It was situated 10-15 cm lower and was covered with 8 cm of water. The soil was not frozen. Each sample was 3 cm deep, and a series was divided into 6 samples, 0-3 cm ..... 15-18 cm. *Folsomia quadrioculata* occurred in the high localities in comparatively large numbers both in the adult and juvenile stages. *Tectocepheus velatus* was fairly common; but the characteristic species were, as on Pl. V, *Platynothrus peltifer* and *Scheloribates laevigatus.*

Animal life at the surface is almost the same in the non-flooded and the flooded locality. But while the fauna is rich in the deeper layers of the high locality (*Oppia, Suctobelba, Variatipes,* and *Tullbergia*), there were no animals at all below the surface layer of the low-lying locality. The reason for this may be the dense structure and the fact that it is flooded. The soil in those layers of the high locality where all pores might be supposed to be filled with water, was frozen. It is possible, therefore, that the flooding in the low locality had an injurious, perhaps a fatal effect on animal life in the deeper layers, where the oxygen content of the soil water is very low or negligible.

Summary.

The supplementary samples from the Plain support the erection of the two main communities.

THE SOUTHERN LINE OF THE PLAIN. Table 15.

As previously mentioned, the line deviates somewhat from the main line. On July 29., 1942 a series of samples were taken from Pls. A, B, and C. The samples from the *Gnaphalium* zone only contained 15 specimens, 5 of which were *Tectocepheus velatus* and 2 *Ceratoppia bipilis*, a species which was not found at all on the main line, but occurred on Rogeshøj. The *Calluna* samples were somewhat richer, 43 individuals being found in one series, half of them *Tectocepheus velatus* (many juvv.). Further, there were 3 *Carabodes marginatus* and only 2 *Folsomia quadrioculata.* The *Juncus* samples showed the same dominance of *Tectocepheus velatus*; in addition the upper layer contained 12 *Variatipes qua-*

drangularis, 6 *Tarsonemoides belemnitoides*, and 6 *Oppia minus*, but only 4 *Folsomia quadrioculata*. Only 3 animals were found in the deeper layers.

Judging by these examples, the fauna from the southern line of the Plain cannot be compared to that of the main line, and this is no doubt due to the presence of ling and ling humus. It resembles the fauna of Revlinghøj most.

THE MEADOW AND THE SOUTHERN MEADOW

As already mentioned, these localities are moist, and as a matter of fact we find *Platynothrus peltifer* and *Malaconothrus globiger* here.

The Meadow. Jan. 23., 1942 (M. samples 2-4). The earth was frozen down to a depth of 10 cm. The samples are from depths of 15, 45, and 70 cm.

The dominant species at a depth of 15 cm were *Pseudotritia monodactyla*, *Proisotoma minima*, and *Hoploderma striculum* as well as *Tyroglyphid* deutonymphs. The presence of the numerous *Pthiracaridae* may be explained by the fact that the earth, as already mentioned, is filled with rotting bits of branches, and the *Pthiracaridae* are known for their gnawing of wood (Jacot 1936, Forsslund 1943, pg. 167). It might be imagined that the paths of the large earthworms might function as »roads of infection«.

. April 1., 1942. The period of thaw. 4 samples were taken, 2 inside and 2 outside a large *Deschampsia caespitosa* tussock, for the purpose of ascertaining whether there was any difference between the fauna in the two habitats. Each sample was 1/1000 sq. m and was taken from depths of 0-8 cm.

The samples from the grass tuft contained most of the animals, about 40 specimens per sample, apart from the *Tyroglyphid* deutonymphs, while the samples from outside the grass tuft each contained about 30 animals. The difference in the number of individuals is not striking, but if the individual species are considered it is found that the species outside the grass tuft are on the whole smaller than those within the tuft. The chief species in the grass tuft were *Liebstadia similis*, *Scheloribates laevigatus*, *Oribatella berlesei*, and *Platynothrus peltifer*, whereas the number of these large species outside the tuft was considerably less. Here, on the other hand, *Tullbergia krausbaueri*, *Brachychthonius sellnicki* and a number of *Tarsonemini* occurred. The habitats in fact differ a great deal; while the tuft throughout the whole lenght of the sample is pierced by long channels, only the surface layer of the bare soil is so loose that it can offer space for the larger species. Small forms, on the other hand, can live in the deep layers. It is noteworthy that *Folsomia quadrioculata* and *Tectocepheus velatus* only occur outside the tuft.

The Southern Meadow. On June 6., 42, 2 series of samples were taken among the vegetation; depht 0-3 and 3-6 cm. The upper layer contained 95 and the lower one some 20 individuals. *Hypogastrura armata* was entirely

dominant in the layer 0-3 cm, and probably it occurs almost exclusively in the uppermost centimetre, at any rate only one specimen was found in the layer 3-6 cm. A characteristic feature of the samples is the occurrence of numerous *Scutaridae* (especially *Variatipes quadrangularis*), *Malaconothrus globiger*, *Platynothrus peltifer*, and *Scheloribates laevigatus*. The community is a mixed *collembolan* and *oribatid* community with a good many *Scutacaridae*, and it is characteristic that animal life in the deeper layers is considerably richer than in the low localities of the Plain (greater pore size). Even comparatively large species occur in the layer 3-6 cm: *Isotoma viridis* (young ones), *Malaconothrus globiger* (adults and nymphs), *Platynothrus peltifer* (nymph), and *Scheloribates* (nymphs).

ROGESHØJ (Table 17).

2 series of 3 samples each were taken from moss and raw humus on July 8., 42.

1. H, samples 1 and 4, moss (a cushion of *Dicranum scoparium*)
2. H, sample 2, the raw humus below the preceding samples. 0-4 cm.
3. H, samples 3 and 6, raw humus 4-6 cm.

The microfauna of Rogeshøj is entirely different from the fauna in the preceding localities.

About 300 animals were found per 1/1000 sq. m, the main part in the moss and in the uppermost 4 cm of the raw humus. The number of individuals at a depth of 4-8 cm was, however, considerable.

The characteristic forms in the moss layer were *Oppia splendens*, *O. quadricarinata*, *Notaspis coleoptratus*, *Brachychthonius brevis*, *Br. perpusillus*, *Scheloribates pallidulus*, and *Galumna nervosus*.

The first of these species are known both from moist and dry localities, *Scheloribates pallidulus* from stumps of trees, while we have no special information about the *Brachychthonius* species. *Galumna nervosus*, on the other hand, was only found in moist and very moist localities. As previously mentioned, the moss is in addition densely populated by *Trombidiformes*, of which *Reteiydeus catenulatus*, *Brachychtydeus breviculus*, and *Nanorchestes arboriger* may be mentioned. All these species are known from moss (THOR 1933).

The fauna of the raw humus layer is of another type; here the small *Suctobelba* and *Brachychthonius* species are dominants. In addition the large *Nothrus silvestris* is found in considerable numbers. The *Suctobelba* species are common everywhere in humous soils. It is a peculiar fact that the *Brachychthonius* species in the moss are different from those of the raw humus, where *Br. cricoides* and *Br. zelewaiensis* dominate. The last mentioned is known from bogs and other moist localities (SELLNICK and WILLMANN). *Nothrus silvestris*

has been found in moist meadows and forests. The *Trombidiformes* were represented in this layer by *Nanorchestes arboriger* and *Coccotydeus frequens*. In the layer 4-8 cm animal life was poorer. The species were the same as in the uppermost layers of humus, but usually only the small forms were present; here too *Suctobelba* and *Brachychthonius* species dominate.

REVLINGHØJ

Table 17, R. samples 5-8.

April 1, 42. Samples from raw humus and white sand.

June 30, 42. Samples from moss and raw humus.

It is characteristic that animal life in the thin raw humus is considerably poorer than on Rogeshøj. The bulk of the animals were found in the moss where *Tectocepheus velatus* is dominant. *Oppia splendens* did not occur, whereas *O. fallax* was present. *Brachychthonius cricoides*, *Nanorchestes arboriger*, *Triophtydeus pinicolus*, and *Coccotydeus claviger* must also be mentioned.

Below the raw humus there were scarcely any animals.

Both on Rogeshøj and on Revlinghøj *Zercon curiosus*, which FORSSLUND (1943) found in forest humus in northern Sweden, was observed.

Altogether the fauna on Revlinghøj and Rogeshøj is highly reminiscent of the raw humus fauna which was found by FORSSLUND in the northern Swedish forests; *Oppia*, *Suctobelba* and *Brachychthonius* species seem to be characteristic of these localities.

COMMENTS AND DISCUSSION

Some of the factors which may be supposed to be of significance for the composition and the distribution in nature of the microfauna will be discussed in the following sections. But it will be reasonable first to mention the conclusions which have emerged from investigations of similar localities. The only work which can be considered in this connection is FRENZEL (1936).

The works of HAMMER (1934-37) and TUXEN (1943) are of less interest in this connection, since their localities in Greenland and Iceland do not seem directly comparable with the Plain.

FRENZEL's types of localities on the whole resemble the Danish types of meadows, and it is characteristic that the species occurring in the moist part of the Plain have nearly all been found in the Silesian meadows, and this, of course, affords an important basis for a comparison between FRENZEL's and my localities.

FRENZEL found (pgs. 102-107) that the number of *Oribatidae*, *Parasitiformes*, and *Trombidiformes* was as 10:3:2. In other words, the *Oribatidae* entirely dominate the fauna; but in addition FRENZEL showed that the number of the *Oribatids* in the total subterranean fauna decreased rapidly with the depth, whereas the number of the *Parasitiformes* and *Trombidiformes* rose proportionally. FRENZEL further points out that animal life below the surface in the very moist *Cyperaceae* meadow at Nippern is very poor, and he thinks that this paucity is caused by the regular inundations. Unfortunately FRENZEL's descriptions of localities are not very complete, thus he does not mention the fabric of the soil. Moreover the occurrence and number of the species in the individual samples is not stated. But as will be seen, the above mentioned results are in excellent agreement with the conditions found in the lower lying localities on the Plain and in the Meadow, where the *Trombidiformes* played a subordinate part, and where the proportion of *Gamasidae* in the fauna was relatively high.

On the other hand, I have not seen any literature dealing with the microfauna in localities comparable with the dry part of the Plain. — Most simila-

rity is to be found in HAMMER's description (1934, pg. 10, 1937, pg. 11) of the mite and collembola fauna of the Greenland fell-field (cp. p. 180), and as previously mentioned, *Folsomia quadrioculata* is the dominant species there. But in addition HAMMER found several large *Oribatids* and very few *Trombidiformes* in this dry locality. — TUXEN (1943, pg. 332) mentions the *Oribatid* fauna in *Dryas* tufts, grass vegetation, and on bare spots on the dry »melar« in Iceland (cp. p. 214), and he noted that while *Trypochthonius tectorum* was dominant in the tufts, and *Scutovertex minutus* was the most numerous form in the grass, *Tectocepheus velatus* dominated outside the vegetation.

Beyond the information is very scattered and sparse.

As has already been mentioned, the fauna on Rogeshøj and Revlinghøj recalls that found by FORSSLUND in the forest soil of northern Sweden.

It was shown on p. 219 that the microfauna responds readily to changes in the ecological factors, and so there is reason to consider the significance of the individual factors.

The ecological factors.

In the preceding sections the importance of the water content for the microfauna has often been referred to; the *Folsomia-Variatipes* commnnity and the *Tectocepheus-Scheloribates* community were erected on a purely physiognomical basis, but it was shown and confirmed by the supplementary samples that the former community was found in the part of the Plain independent of the ground water, and the latter in the part dependent on the ground water. So the water content must be regarded as a significant factor (p. 219). But further, it was emphasised (p. 221) that the water content alone would not account for the occurrence of the individual species. For instance, *Variatipes quadrangularis* and *Brachychthonius berlesei* usually inhabit both moist and and dry localities, while their occurrence on the Plain is restricted to the dry localities, and *Tectocepheus velatus*, *Folsomia quadrioculata*, and several other »ubiquists« are frequently found in great numbers in localities with a very different water content. The distribution of these animals must therefore be dependent on other factors than the water content. Here we may turn our attention to the factors of space, protection and nourishment. Space and protection may be combined into one factor termed structure.

The greater part of the soil organisms live directly or indirectly on humus, while only a small part are autotrophic. The organic substances in the soil are derived almost entirely from the macrophytic vegetation (moss and lichen included), the composition of which controls the amount and nature of the humus. The factor which must be considered of the greatest importance for the vegetation and the metabolism is the water status (cp. BRAUN-BLANQUET

1928), and from this it will be seen that the water content must be regarded as a factor of primary importance.

The water content of the soil.

Water is a variable form-component (p. 169). If a soil is flooded all its pores are filled with water, the locomotion of the animals is impeded, the exchange of oxygen between the deeper layers and the surface is very slight and the oxygen uptake of the animals is rendered impossible. The maximum amount of oxygen per unit volume of soil is less in a water-logged soil than in one filled with air, and all aerobic fungal and bacterial processes must gradually cease. Finally the earth falls in, so that the number of large pore spaces is reduced. So it is natural, that animal life is very pore in the deeper layers of flooded localities, and no doubt the inundations are directly or indirectly the cause of the small amount of subterranean animals on the low lying localities of the Plain. The injurious effect on earthworms, whose activity is of such importance for the structure of the soil, has been pointed out by KOLLMANNSPERGER (1934).

It has been shown that the water content expressed in per cent of the dry matter cannot be used as a basis for comparison of the water content of soils essentially different, and it was emphasised that the water content in layers with a dense net of roots should be divided into two fractions, root water and free water (pg. 182). The ratio between the free water and the humus content should — if the grain size be duly considered — partly give a better indication of the moisture conditions to which the animals in the pores are exposed, and partly afford a possibility of estimating the moisture of the organic remains; this is of significance, inter alia, for their consistency and microflora. But it was also proved that the ratio between free water and humus may be almost the same in moist and in dry localities, when calculated on the basis of the average annual water content, whereas in the course of the year the ratio in the dry localities undergoes much greater fluctuations than is the case in the moist ones. Thus in dry localities it is in some periods so small that the relative humidity of the air of the pores is less than 100 p. c., whereas the air in moist localities is always saturated with water vapour (cp. THAMDRUP, 1939). Hence the importance of an analysis of the variations of the water content is obvious. — The investigation has not shown any correlation between maximum of water content and maximum of fauna. The maximum number of individuals was reached in a period with constant water content and relatively high temperature, the autumn.

Platynothrus peltifer and *Malaconothrus globiger* were only found on the Plain below Pl. IV, and these species, only occur in constantly moist localities. The

actual reason for this fact is not known, however. Thus the adults *Platynothrus* will tolerate a stay in dry air for some time (according to experiments made in Juli 1944: 3 hours or more at 15 p. c. R. H. and 18° C.). And conversely *Folsomia quadrioculata* shows very little resistance to desiccation. The *Oribatidae* are most frequently found in moist localities; but few species seem to require so constant and plentiful water supply as the above mentioned. *Scheloribates laevigatus* and *Peloptulus phaenotus*, both of them large species, are thus common on Pl. IV. The resistance to desiccation of these species is greater than e. g. that of *Folsomia*, as found by cultivation experiments, but desiccation for a prolonged period is always fatal. Hence the species will not be able to survive in the high lying localities, for on account of their size they are unable, in case of drought, to go down into the deeper layers.

Content of organic matter.

It has been mentioned that organic matter forms the basis of the life of most soil organisms, and is therefore of the greatest importance for the animals. However, a high content of humus is by no means equivalent to a rich mite and collembola fauna (Pl. VII), and a soil poor in humus may harbour a comparatively rich fauna (Pl. I). Further, it must be kept in mind that a soil with even a very large annual supply of organic matter may be relatively poor in humus, because the metabolic intensity is very great, and life thus very luxuriant. The formation of raw humus, for instance, is almost unknown in the tropics, whereas it becomes more frequent the farther we go northward where the annual supply steadily diminishes.

The chemical composition, structure and consistency of the organic substances is no doubt of great importance for animal life and as far as the microfauna is concerned it manifests itself in the difference between the fauna in mould and humus soil, e. g. the Meadow and Rogeshøj (cp. Bornebusch 1930).

The significance of the organic matter for the water content has previously been mentioned.

Root Content.

The roots are an active form component (p. 179) and it was shown (p. 180) that the amount of roots in a grass field may constitute a considerable part of the total amount of organic matter in the layers which are especially inhabited by mites and collemboles. This renders justifiable the distinction drawn between root water and free water. Of the direct significance of the roots for the microfauna this investigation gives no information (f. i. concerning the O_2 and CO_2 content of the soil).

A large root content does not guarantee a rich microarthropod fauna. (As regards the parasitic *Nematodes* the case is of course different). In the estimation of the significance of the roots one must keep in mind that it is probably of an indirect kind, since the bulk of the organic substances in some localities is derived from the roots. Thus for instance the greater part of the organic matter in the soil of a permanent pasture like the Plain consists of decayed roots while in a forest with little undergrowth (e. g. a dense beech forest) it is made up of leaves and twigs. *Calluna* humus is composed of many different remains, such as leaves, twigs, moss, and roots. A determination of the root content should therefore be included in the description of the habitat.

The structural factor.

The space factor. It has been emphasised several times and it also appears from Figs. 15-17 that the large species in the localities of the Plain were not found in the deeper layers, nor are they able to move about there. In other localities, on the other hand, where the soil has crumb structure, the same species were found several centrimetres below the surface. The space conditions must therefore be of importance for the occurrence and frequency of the species. The typically subterranean species on the Plain are all small or very small (100-200μ), and they are thus able to inhabit the microcaverns and are not dependent on the passages of earthworms and similar larger channels.

The bulk of the animals on the Plain are denizens of the topmost centimetre of the soil. If we assume that in the Southern Meadow and on Rogeshøj the animals are evenly distributed throughout the topmost centimetres, as the deep samples would seem to indicate, we should find (1942), that the number of individuals per 10 c.cm of the surface layer from the Southern Meadow or humus from Rogeshøj (40-50 specimens) is not essentially higher than in the upper 10 c.cm (sample 0-1) on Pl. VII (44 specimens) at the same period. It will be seen, then, that if a particular locality is to be characterised faunistically it will be reasonable to calculate the number of individuals per surface unit of area. This will give some idea of the production and metabolism of the locality. But if the object is to find the ecological valency of the species on the basis of the frequency values found in nature, the number of individuals per habitable volume unit must be calculated. For the present it can only be estimated, but a reliable method of analysis should not be beyond the bounds of possibility.

In connection with our discussion of the space factor it will be convenient to explain how the term »microfauna of the soil« can be defined. It cannot be done by reference to any larger systematic groups, for in most groups we

have examples of species that may occur outside the soil, e.g. in water, and in addition they usually contain forms which are too large to be included in the microfauna. The natural procedure would be to define the microfauna of a soil as those individuals of the total fauna which are so small that they are able to move freely in the pores of the earth and are not directly forced to change the structure of the soil by burrowing. The term »microfauna« will then be a term denoting size; but which animals should, according to the definition, be included in the microfauna will depend on the pore size of the soil. In fine-grained dense soils the animals must be small, in soils with crumb structure larger forms too may be included in the microfauna. Thus the term is relative. The use of it implies a knowledge of the size of the animals and of the pores of the soil and nothing else. While according to this definition it will be clear that the macro- and the microfauna differ in soil-biological importance, conversely, a particular soil will offer different conditions to the two fauna elements, the macrofauna being partly able to create its own environment (the soil), while the microfauna is to a much higher degree dependent on the soil and the environment-creating work of the macrofauna (see p. 245). — The ecological difference between the macro- and microfauna will thus be apparent. The macrofauna could therefore (within the bounds of possibility) be called an environment-creating fauna element and the microfauna could be called an environment-receiving element. Nothing prevents us from including an animal species in the microfauna in a coarse soil, while in another locality where the soil is fine-grained, the same species is principally associated with the surface and therefore appears as a surface animal (e.g. *Isotoma viridis* and *Collembola* of forest ground). The distinction which many authors draw between the hemiedaphic and the euedaphic soil fauna will thus be obliterated, and as a matter of fact it is impossible to decide in general whether a species belongs to one or the other group. In the case of animals occurring in the deeper layers of a locality we may speak of a subterranean occurrence.

The factors of protection.

While it is thus clear that the animals must have room to move it is important, on the other hand, that the surroundings should also yield protection for instance against light, desiccation, and animals of prey.

Light and desiccation. Most soil animals are photophobic. This applies for instance to many *Oribatidae* (Michael 1885 and others), and I have observed that *Scheloribates laevigatus,* when in light, goes under the moss at the bottom of the cages, while in the dark they creep about freely on the

top. (On the Plain I found the animals early in the morning moving freely on the surface among the vegetation). The habitats must therefore afford protection from strong light. In all the localities, however, the vegetation was of such a nature that the light — except on the bare areas of Pl. I — would not have been a direct limiting factor.

Desiccation is of course dependent on the moisture of the soil, but even though the water content in the depths of the soil is comparatively large the animals on the surface of the dry localities may be much exposed to desiccation. In the lower lying localities the surface is always moist and the dense vegetation affords protection from evaporation. In the higher localities where plants with a horizontal growth predominate, the leaves of these also check evaporation to some extent, but in periods of drought the sand under the leaves also dries up entirely and the animals have to descend to the deeper layers. These wanderings cannot be verified from the material collected, but the principle of the BERLESE and the TULLGREN apparatus is based precisely on the assumption that the animals, when the surface dries up, descend to the deeper layers and there is no reason whatever to believe that something similar should not occur in nature to a greater or lesser extent. In the localities exposed to desiccation it is of importance, therefore, that the deeper layers can offer the surface dwelling forms habitats protected against evaporation.

Animals of prey. The animals that especially prey upon mites and collemboles are *Gamasidae* and *Staphylinidae*. Further, I have found that the young of *Opilionidae (Phalangium opilio)* have consumed cheese mites in great quantity (in darkness), and it is therefore probable that in compost heaps, forest ground, etc. these animals, at any rate in the juvenile stages (spring and summer), are important predators.

I have carried out a number of feeding experiments with *Gamasidae* and have kept some species in cages for about 1½ months. They were: *Eulaelaps* species, *Eugamasus furcatus*, *Macrocheles* species, *Pergamasus crassipes*, (adults and nymphs), *Arctoseius bispinatus*, and finally *Zercon suecicus*. I have ascertained that all these species have fed on cheese mites, except the small *Arctoseius* species. Thus most of the individuals throughout the experimental period lived on cheese mites. It was characteristic, however, that usually the animals could only dispose of thin-skinned larvae and small nymphs, whereas they shunned the large nymphs and the adults, whose chitin they were not able to break.

If the animals were starved for several days and then fed with nymphs they, however, attacked them, but it was characteristic that they never succeeded in overpowering their victim if they attacked it from behind. Thus on the June 4. 43 I observed that a nymph of *Pergamasus crassipes* attacked

a large cheese mite nymph from behind and began to belabour it with its chelicerae. But immediately afterwards it darted back and began to clean not only its chelicerae but also the tarsi on its first pair of legs which are used as sense organs (cp. HAARLØV 1943). This seems to indicate that the cheese mite gave off a defence secretion and, it seems natural to assume that it might be derived from the large yellow oil glands (the expulsory vesicles, MICHAEL 1883) on each side of the hysterosoma. These glands are well developed in *Tyroglyphus farinae* and are also present in many *Oribatid* nymphs. They are, for instance, very large in *Scheloribates laevigatus*. If an attack on a large cheese mite was to be successful, the animal must be attacked from in front; here the skin of coxae 1 and 2 seemed suitably thin.

If the large species of *Gamasidae* were put in the same cages as *Folsomia quadrioculata* all the smaller *Collembola* were devoured in short time, and it must be taken for granted, therefore, that the *Gamasidae* may influence the number and occurrence of the smaller *Collembola*. However, all the *Gamasidae* seemed to prefer nematodes. If cheese mite larvae and nematodes were put into the cages at the same time the *Gamasidae* first devoured the nematodes and seemed first to become aware of the presence of these animals. It is probable, therefore, that the food of the *Gamasidae* consists in great part of nematodes, which occur in very great numbers in the soil (MICOLETZSKI 1921, FRANZ 1943). Even the *Eulaelaps* species living in the cheese mite colony preferred nematodes.

Like the *Gamasidae*, the *Staphylinidae* larvae prey on collemboles and cheese mites but these animals were even able to dispose of the adults.

Judging from the above, *Gamasidae* and *Staphylinidae* must be regarded as animals of prey that may reduce the number of *Collembole* and *Oribatid* nymphs, and the importance of a substratum having a structure suitable for the food animals may easily be ascertained by the following experiment. In a bare glass containing *Collembola* and *Gamasidae* the *Collembola* are soon devoured, while they are able to survive for a considerably longer time in a glass with a substratum of moss or the like. This is due to the increased hunting ground, which involves that fewer animals are present per unit of area, and the chance of catching a food animal is therefore reduced accordingly, as the *Gamasidae* do not perceive the animals until they are quite close to them. Furthermore the porous substratum will offer some *Collembola* niches which is so small that the larger *Gamasidae* cannot get hold of them there.

The structural factor is undoubtedly of great importance for the quantitative and qualitative composition of the microfauna in the localities of the Plain.

The fabric of the surface of the soil on Pls. I and II can be compared to that of a sponge; the soil is throughout composed of comparatively large

pores. The pores are so wide that *Folsomia quadrioculata* which dominates in the localities can easily move about in the pore-net (see Fig. 15). On account of the growth form of the vegetation the free surface of the soil, is larger and more or less covered with leaves affording a shelter against evaporation and light. The number of traversable microcaverns per surface unit is very great, but in periods of drought the whole surface of the soil may dry up. This structure agrees well with the composition of the fauna:

1. Small forms: The pores afford protection.
2. Large forms rare: No protection against eventual dessiccation of surface layers.
3. Relatively many animals per unit of area: Large free surface with a large pore system, plenty of space.

The fauna in the dense grass vegetation is subject to other conditions. Here the free surface of the soil is small since the stems are quite close together. The pores are partly filled up. The surface is protected against evaporation and light by the vegetation, just as the soil is more moist. But on the surface or on the lower parts of the plants the animals have but slight protection from preying animals, and it is indeed characteristic that in the grass vegetation the small thin-skinned *Trombidiformes* have been replaced by larger thick-skinned *Oribatidae*. We thus have:

1. Large formes: protection against evaporation.
2. Few small forms: small pore-net, no protection agains animals of prey.
3. Fewer animals: small free surface.

The nature of the walls of the microcaverns may also affect the animals. The *Oribatidae* can only with difficulty move on smooth surfaces on account of their large and rigid claws. The pads of the *Gamasidae* dry up when they move on dry surfaces. This may happen very quickly, as I have convinced myself by tolerance experiments where such possibilities must be taken into consideration. Moist surfaces prevent the movements of long-haired forms. Thus the long hairs of *Glycyphagus* (*Oudemansium*) easily adhere to moist walls and thus stop the animal. Very hairy forms are indeed as a rule surface animals. Thus the corticolous *Collembola* are characterized by their large scales (e. g. *Sira*) or long hairs (e. g. *Achorutes*). (See also GISIN 1943).

The food factor.

In addition to the factors mentioned in the preceding part other things must be taken into consideration too. FRENZEL (1936, pg. 18) and AGRELL (1941, pg. 136) do not think food of decisive importance for the occurrence of the animals. They only consider the amount of the food, not its nature. FORSSLUND (1943, pg. 162), on the other hand, points out the importance of this fac-

tor, and we have previously indicated that the differences in the food conditions might explain the occurrence of some species. It is at any rate characteristic that the fauna in the Meadow and the Rogeshøj is widely different, while the structure and moisture conditions bear a great resemblance to each other.

The nourishment of the *Collembola* and the *Oribatidae* (Handschin 1926, pg. 17, Agrell 1941, pg. 126, and Forsslund 1936 and 1933, pg. 167), consist in great part of fungal hyphae, but a good deal of unformed detritus is often found in the gut of the *Collembola*. The bacterial and fungal floras are quite different on mould and on raw humus, and it is natural to suppose that here the food conditions would be of decisive importance for the occurrence of the animals.

It has been stated that the *Collembola* often feed on algae. Practically no algae were found in the dredged samples from the upper layer of the Plain, but it is possible that this is due to the long period of drought before the sampling. However, algae do not seem to occur in any great quantity on the plain.

Differences in the hydrogen ion concentration are so small on the Plain that no great significance can be attached to them. It is probable, however, that the hydrogen ion concentration in other localities may be important since the fungal and bacterial flora is very largely dependent on the reaction of the substratum. Gisin (1943) found characteristic differences between the »euedaphic« *Collembola* fauna in localities with a different pH. He evidently regarded the hydrogen ion concentration of the soil as being of direct importance for the *Collembola*; he writes (p. 193): »Hier sei daran erinnert, dass die meisten Collembolen eigentliche Erdfresser sind, was an ihren Darminhalt ersichtlich ist.« — But it can by no means be taken for granted that the solution is so simple.

Thus Kollmannsperger (1934), found that species of earthworms which must be designated »true soil feeders« since they may occur in soils which are only periodicelly covered with litter, were found in soils of very different degrees of acidity. This is also illustrated by an investigation I made in June 1944 of the earthworm fauna on the steep S-E bank in a beech forest at Fuglevad (near Copenhagen).

The slope was composed of fine grained sand of which the upper 20 cm contained humus while the subsoil consisted of fine yellow sand. On the slope bare places and areas covered with vegetation alternated. The vegetation consisted of *Poa nemoralis, Dactylis glomerata, Aegopodium podagraria, Majanthemum bifolium, Convallaria majalis, Chamaenerium angustifolium, Urtica urens*, and others, and it contained representatives both of the mould and the humus flora. On the covered as well as on the bare areas there were many earthworms, and in equal numbers. It was exclusively *Allolobophora caligi-*

nosa (f. typica = All. turgida). The pH was measured in fresh soil samples, partly in distilled water, partly in a KCl solution, by means of a ionometer with a kinhydron electrode. The results are marked in the table below.

Locality	Depth	pH in water	pH in KCl
Top of slope	surface soil (cov. w. vegetation)	8,1	7,2
	surface soil bare	4,6	3,7
	surface soil bare	4,7-8	3,9-4,0
Middle of slope	surface soil (cov. w. vegetation)	8,0	7,1
	subsoil	8,2-3	7,4

Some control samples were taken, and it is seen that pH in the areas covered with vegetation is essentially higher (c. 8,0) than in the bare areas (c. 4,5-5,0) which must be termed very acid. The earthworm fauna, however, does not seem to be affected by it. — Further, HANDSCHIN (1936, pg. 17) found that the typically euedaphic animal, *Tullbergia krausbaueri*, could live exclusively on fungal hyphae for several weeks.

The influence of other organisms.

From the above remarks the significance of the fungal and algal flora for the mites and collemboles will be obvious. But as shown by DARWIN (1841 and 1880) and MÜLLER (1884), and by many others, many organisms greatly influence the structure and altogether the qualities of the soil. Notably the importance of earthworms for the belabouring and metabolism of the soil has been emphasised. We have seen, however, that the microfauna depends greatly on the structure of the soil and through the food factor probably also on the metabolism of the soil. The significance of the earthworms is thus obvious. If we review the fauna in the various localities according to FRENZEL's tables 1936, it is evident that in the localities where the earthworm fauna is most abundant, there is also the greatest microfauna, the »euedaphic« species being especially numerous. — In localities where there are few earthworms, the microfauna b e l o w the surface is poorer and contains comparatively few »euedaphic« species.

Thus it will be seen that if we are to understand the quantitative and qualitative composition of the microfauna, we must not only take into consideration the physical and chemical factors, but also largely consider the other organisms in the soil, in comparison with which mites and collemboles only constitute a small part.

SUMMARY

The microscopical arthropod fauna in different soils has been investigated by means of BERLESE samples. The main material derives from a sampling line, 12 metres long, and situated on a sandy permanent pasture, the Plain. The sampling line represents a moisture zonation, the higher, temporarily dry, part being covered with a *Gnaphalium arenarium* — *Hieracium pilosella* sociation, the lower, constantly moist, part with a *Carex demissa* — *Hieracium auricula* sociation.

1. The qualitative and quantitative description of the 7 localities on the sampling line comprises: the vegetation, root content, the ground water fluctuations, variations in water content during the year, tensional force, the structure of the soil (especially pore size), temperature, and p. H. The root content, the moisture conditions, and the structure are especially dealt with (pgg. 168-191).
2. The water of the living roots (root water) constitutes a considerable part of the total water content of the uppermost layers. The root water must be taken into consideration when the moisture conditions of the soil humus are discussed and when the F-value (see pgg. 184-188), so important to all microorganisms, is calculated.
3. In an atlantic climate like that of Denmark the average water content of the soil during the year does not indicate distinctly whether a soil is moist or dry, whereas the variations in water content, F-value, and tensional force are much more indicative.
4. The size of the microcaverns (pore size) often corresponds to the size of the microarthropods, thus being a limiting factor in certain soils.
5. 145 species of microarthropods are identified, many of them not previously known from Denmark. The species are distributed as follows: *Gamasidae* 17, *Trombidiformes* 45, *Oribatidae* 53, *Acaridiae* 4, *Collembola* 26. 10 mites (pg. 199), new to science, are described in the Appendix.
6. Corresponding to the successive changes in the ecological factors (especially moisture conditions, structure, and nature of the organic remains)

successive changes in the composition of the fauna are met with, both concerning species and larger groups *(Oribatidae, Trombidiformes)*.

7. In spite of these successive changes between the faunas in neighbouring localities a distinct difference is recorded between the faunas in constantly moist parts and in temporarily dry parts of the Plain, respectively. Thus a dry soil community (*Folsomia-Variatipes*) and a moist soil community *(Tectocepheus-Scheloribates)* are erected. However, the validity of these communities is restricted to the Plain or similar localities (see pgg. 217-220).
8. The examination of several supplementary samples (from the Plain, a meadow, and from *Calluna* localities with raw humus) supports the importance of the following distributive factors: moisture conditions, soil structure, the specific nature of the organic remains (humus, decaying plants etc.), and food. Only the two first named have been treated more detailed (pgg. 237-243).
9. The discussion of the concept of »microfauna« concluded in an ecological characterization of the microfauna in contrast to the macrofauna (pgg. 240), stressing the fact that the microfauna cannot alter significantly the structure of the soil.

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APPENDIX

DESCRIPTION OF SOME NEW OR LITTLE KNOWN MITES

(Acari: Laelaptidae, Tarsonemidae, Endeostigmata, Tydeidae, Eupodidae, and *Hypochthoniidae).*

In the preceding paper (Ecological Studies on Mites and Collemboles in the Soil. Natura Jutlandica I. 1948) some species, not hitherto known, have been mentioned (pg. 199). All the localities referred to have been described there (pgg. 156-97).

Gamasides. Laelaptidae.
Vitzthumia magniscutum n. sp.

The genus *Vitzthumia* was erected by THOR in 1930. He described the species *V. oudemansi.*

Vitzthumia magniscutum possesses all the characteristics of this genus. The only exception is that the anal plate is fused to the posterior part of the ventral integument. Thus *V. magniscutum* has a rather big ventrianal plate with 7 hairs *(magniscutum!)*, instead of a simple anal plate with 3 hairs. — Only females and a single nymph have hitherto been found.

Female. Length: 0,470-0,480 mm. Width: 0,250 mm. Fig. 1-5.

The gnathosoma is not visible from above in specimens not treated in lactic acid.

Dorsal. Fig. 1 and 2. — In untreated specimens the lateral margins are concave (fig. 1). Fig. 2 and 3 show animals treated in lactic acid. — The line of division between the anterior and posterior dorsal scutum is distinct and slightly curved. The anterior part of the peritrematalian plates is seen from above, forming the anterior lateral edges. — The posterior two thirds of the margin of the anterior scutum form a big convex curvature. — The hind and lateral margins of the posterior scutum are distinct but irregular. — The sculpture of the dorsal plates is characteristic. Numerous dots are scattered all over the surface, but in addition rows of bigger dots divide the surface in many irregular polygons. — Chaetotaxis: all hairs on the plates are short

(0,020-0,025 mm). They are more or less flattened, distinctly pectinated, and lancet shaped. The vertex hairs, only, are broad (l. 0.025 mm, w. 0,015 mm), and they resemble the caudal fin of a fish. 20 pairs of hairs on the anterior scutum, only the median 6 pairs form a distinct pair of longitudinal rows. The hairs on the posterior scutum are scattered. The soft lateral membrane is pro-

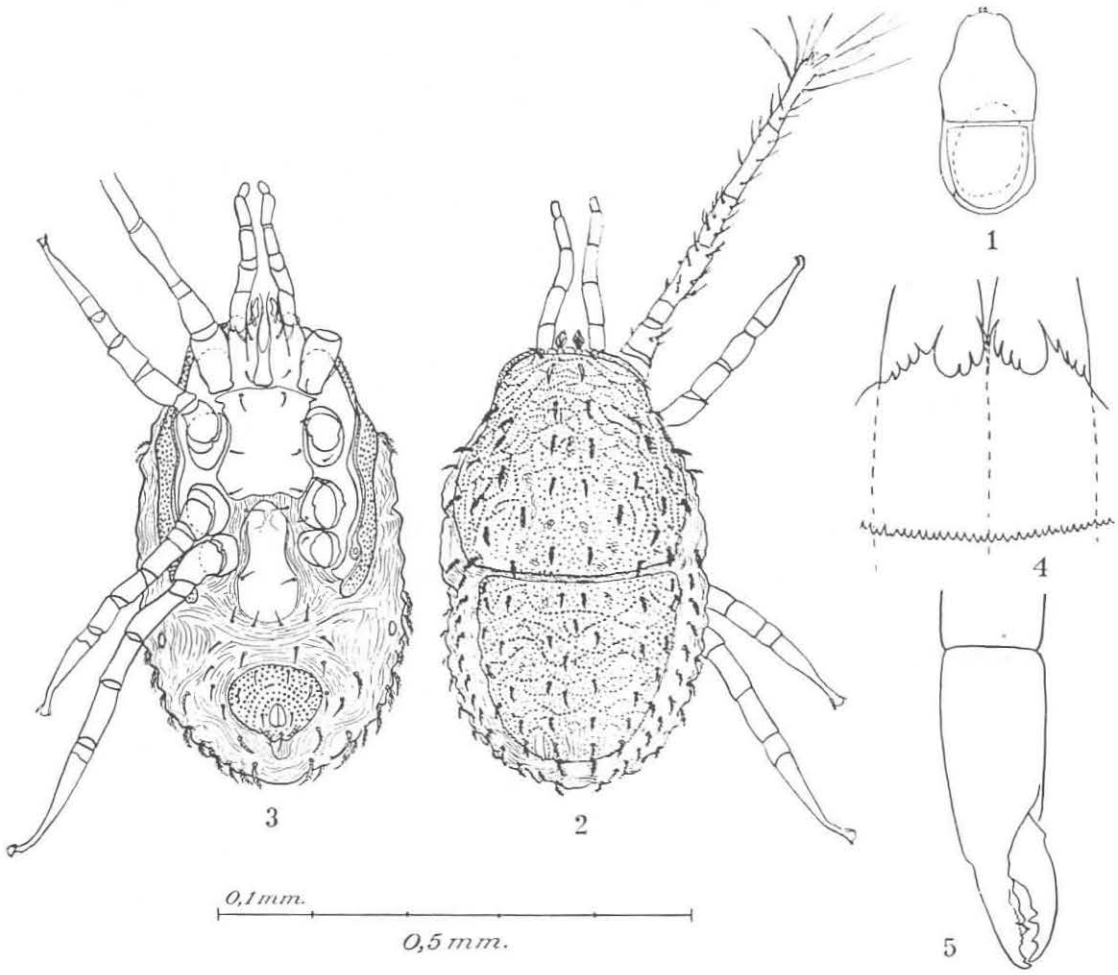

Fig. 1-5. *Vitzthumia magniscutum* n. sp. Female. 1: general appearance, female with one egg. 2: dorsal. 3: ventral. 4: epistome. 5: chelicer, lateral.

vided with numerous hairs of the same type. The integument is distinctly striped and provided with dots.

Gnathosoma. The epistome (fig. 4) is hyaline and the anterior margin has three cusps each with big spines. A curved line consisting of small teeth is present behind the margin. — The palpi are rather long (0,150 mm) and with an armature of simple hairs. The last segment has in addition a bifid hair. — The chelicerae (fig. 5) are slender. Digitus fixus has a lateral molar part and a medial ridge provided with small blunt teeth. Digitus mobilis has two strong teeth, only. The second segment is not swollen (as in THOR's figure). — Corniculi maxillares are of usual shape.

Ventral. Fig. 3. The tritosternum is of usual shape. — Jugular and metasternal plates are lacking. — The sternal plate is short and broad, extending from the posterior margin of coxae I to coxae III. It has 3 pairs of simple hairs and like the genital plate any sculpture is absent. — Simple metasternal hairs are present. — The genital plate is narrow and with concave lateral margins. The anterior margin is curved and smooth (difficult to see) while the anterior part of the plate is faintly striped (perhaps the translucent ventral integument of the genital aperture). — The ventrianal plate has a sculpture resembling that of the dorsal plates. It has 7 simple hairs. The hind margin has a short tongue protruding backwards. Behind this a tongue shaped area of the integument, provided with longitudinal stripes, is present. — The peritrematalian plates are broad and form anteriorly a part of the front margin of the animal. The lateral part is sculptured, the medial part smooth. Between these parts the curved peritrema is seen. The stigma is situated just lateral to coxae IV. — Small oval inguinal plates are seen laterally. — The integument of the ventral area resembles that of the lateral membrane. The hairs are simple anteriorly, but pectinated posteriorly. Stripes and chaetotaxis: see fig. 3.

The legs. THOR (1930) does not mention the tarsus I specially. In my specimens (females) tarsus I lacks praetarsus and claws and has only long hairs and short solenidions. It seems as if (cp. THOR's photographs) the females of *V. oudemansi* lack praetarus I too, whereas the males possess praetarsus I. The other legs have praetarsus and distinct claws. Leg I: 0,420 mm.

Vitzthumia magniscutum (females) differs from *V. oudemansi* THOR: 1) it is smaller, 0,480 (*V. oudemansi* (females) 0,800-0,900 mm). 2) it has a ventrianal plate with 7 hairs (*V. oudemansi* has an anal plate with 3 hairs).

The females carry only one big egg (fig. 1). *Vitzthumia magniscutum* is recorded from the Plain (surface layers).

References: THOR, SIG, 1930. Beiträge zur Kenntnis der invertebraten Fauna von Svalbard. Skrifter om Svalbard og Ishavet. Nr. 27.

Arctoseius bispinatus n. sp.

This minute creature is a common gamasid on the Plain, but it has not yet been found in other localities. Only females are known.

Adults. ♀. Length: total 0,350 mm, without epistome 0,310 mm. Width: 0,150 mm. (Fig. 6-8).

Dorsal (fig. 6). — The dorsal scutum is very characteristic. It is undivided, but possesses two lateral incisions (1/4 of the width) just in front of the stigmata, indicating the usual line of division between the anterior and the posterior scutum. The shoulders are faintly indicated, and the lateral margins

run parallel to each other, posteriorly with a gradual transition to the rounded and smooth hind margin. The setae are all simple and of medium size. They are arranged in six longitudinal rows, the two medial rows with 12 hairs each, including the pygidial hairs. Typical shoulder and vertex hairs are absent, but a pair of rather long and slender hairs is situated on the posterior margin. A pair of very short bristles is inserted between them.

The gnathosoma. Epistome: the epistome is simple and very charac-

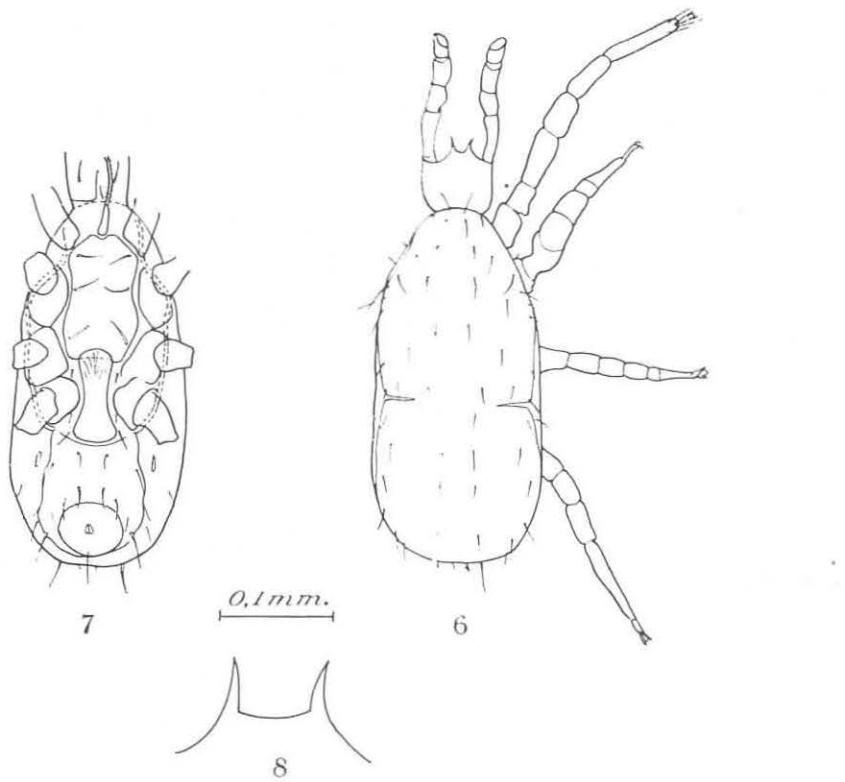

Fig. 6-8. *Arctoseius bispinatus* n. sp. Female. 6: dorsal. 7: ventral. 8: epistome.

teristic (fig. 8). It is light-brown and provided with only two strong spines *(bispinatus!)*. The distance between the spines equals the length of the spines themselves. The palpi are of usual shape and carry a single thick blunt hair on the first and two such hairs on the second segment. The forked hair is distinctly bifid. Corniculi maxillares are of usual shape and pointed.

Ventral (fig. 7). The tritosternum is situated in a concavity in the sternum. It carries two long slender and hairy setae. — Jugular plates are lacking. — The sternal plate extends from the anterior margin of coxa I to the hind margin of coxa III. Shape and chaetotaxis: see figure. — The genital plate is rather small, weakly chitinized, and it is provided with a smooth and rounded anterior margin, which overlaps the hind margin of the sternum. It is a characteristic feature that the genital plate lacks the usual pair of hairs. These hairs are inserted, not on the plate, but laterally to it in the soft membrane —

Metasternal plates are lacking, but the hairs are present. Characteristic too is the presence of a distinct semicircular fold in the membrane between coxae IV and lying immediately behind the genital plate. It is provided with two pairs of simple hairs. — The anal plate is small and rounded with a long postanal hair and a pair of short adanal hairs. — In front of the anal plate 4 pairs of simple hairs are present forming a semicircle. — A pair of small inguinal plates is situated near the lateral margin. — The peritrematalian plates are long and curved. They are not connected with the dorsal scutum in front and extend beyond coxa IV. The peritremata are relatively short, on the contrary; they reach from the stigmata to coxae II.

The legs. The legs are all provided with praetarsus, claws, and pads. Tarsus I is long and cylindrical. It carries a small praetarsus and a minute pad. Distally three solenidia and a single characteristic club-shaped hair are present.

Arctoseius bispinatus resembles *Lasioseius cetratus* SELLNICK 1940. It is distinguished from the latter species by the following features: 1) The dorsal scutum extends all over the dorsal surface. 2) No distinct shoulders are present. 3) The spines of the epistome are relatively longer. 4. The genital plate overlaps the hind margin of the sternal plate. 5) The stigmata are situated lateral to coxae IV (not between III and IV).

The genus *Arctoseius* was erected by THOR 1930. He described the species *A. laterincisus*, rediscovered and redescribed by HAARLØV 1942. I have examined HAARLØV's specimens. It was evident that *A. laterincisus* possesses minute inguinal plates as well as the semicircular fold between coxae IV. Further decription see HAARLOV 1942.

References: HAARLØV, N. 1942. A morphologic-systematic-ecological investigation of *Acarina*. Meddl. om Grønland. Vol. 128. No. 1.

SELLNICK, M. 1940. Die Milbenfauna Islands. Göteborgs Kungl. Vet. Veterh. Samh. Handl. 5. Följden. Serie B. Vol. 6. Nr. 14.

THOR, S. 1930. Se pg. 255.

Tarsonemini. Tarsonemidae.

Genus *Tarsonemoides* TRÄGÅRDH, 1904.

The genus *Tarsonemoides* was erected by TRÄGÅRDH, 1904. He described *T. termitophilus*. It was not until 1942, when WILLMANN described *T. uliginosus*, that the genus became known from Europe. These animals are very small and delicate objects, and therefore my descriptions are of a provisional character.

Tarsonemoides uliginosus WILLMANN 1942 is provided with a special structure, named by me the lobus. The lobus is a thin tongue-shaped extension of the ventral metapodosomal segment, protruding backwards between the coxae

III. Morphologically it seems to correspond to the well developed dorsal mantles (»Mantel« OUDEMANS 1931). — The following remarks may supplement the description by WILLMANN: 1) The lobus is long and with parallel margins, like a blade of a blunt sword. 2) Trochanter IV is large and conspicuous.

I only found 2 specimens (the Plain and Rogeshoj).

Tarsonemoides belemnitoides n. sp.

L. 0,160-0,170 mm. W. 0,095-0,100 mm. Fig. 9-10.

Colour: like amber, but the green gut is always conspicuous. — Surface of integument: quite smooth and shiny.

Dorsal (fig. 9). The gnathosoma is not seen from above except the tip of the palpes. — The propodosoma is of medium size. It carries two pairs of simple hairs, the posterior pair being long and strong.

The pseudostigmal organs are distinct, they consist of a short shaft and an eggshaped head. Between these organs and the anterior pair of hairs a pair of minute pores is present, situated at the lateral margin. Perhaps they represent the stigmata (compare *Pygmephorus*, *Tarsonemus*, and *Pediculopsis*). — The hysterosoma is provided with three mantles. The first is by far the largest and carries the distinct shoulder hairs and a pair of hairs at the posterior margin. The third mantle is hidden below the second.

Ventral (fig. 10). The front margin of the camerostome is situated close to the anterior margin of the propodosoma. The sutures between propodosoma and hysterosoma and between metapodosoma and opisthosoma are distinct. The lobus is long as in *Tarsonemoides uliginosus* but in *T. belemnitoides* it is distinctly pointed, much like a belemnite. — The sutures between the coxae: see figure. — The trochanter III very large, whereas the trochanter IV is as small as in the genus *Tarsonemus*. — The genital aperture seems to be a simple longitudinal fissure between coxae IV.

The legs are of usual appearance.

This species much resembles *Tarsonemoides uliginosus* WILLMANN, but in contradistinction to the latter *T. belemnitoides* has 1) a pointed lobus and 2) small trochanter IV.

T. belemnitoides is met with in the Berlese samples from the Plain, the dry as well as the moist localities, but it only occurs in small numbers.

Tarsonemoides brevilobus n. sp.

L. 0,165 mm W. 0,095. Fig. 11-12.

Dorsal (fig. 11). Contour: oval. — The anterior lateral borders of the propodosoma are slightly concave. The front hairs are distinct, and the pores (stigmata?) are situated at the lateral margin close to the insertion of these hairs. The posterior hairs of the propodosoma are very long and slender (see

figure). — The mantles are poorly developed and difficult to distinguish from each other. — The hind margin of the opisthosoma is slightly concave. — Chaetotaxis: see figure, compare *T. belemnitoides.*

Ventral (fig. 12). The front margin of the camerostome is situated a short distance behind the anterior border of the propodosoma, thus the mouth

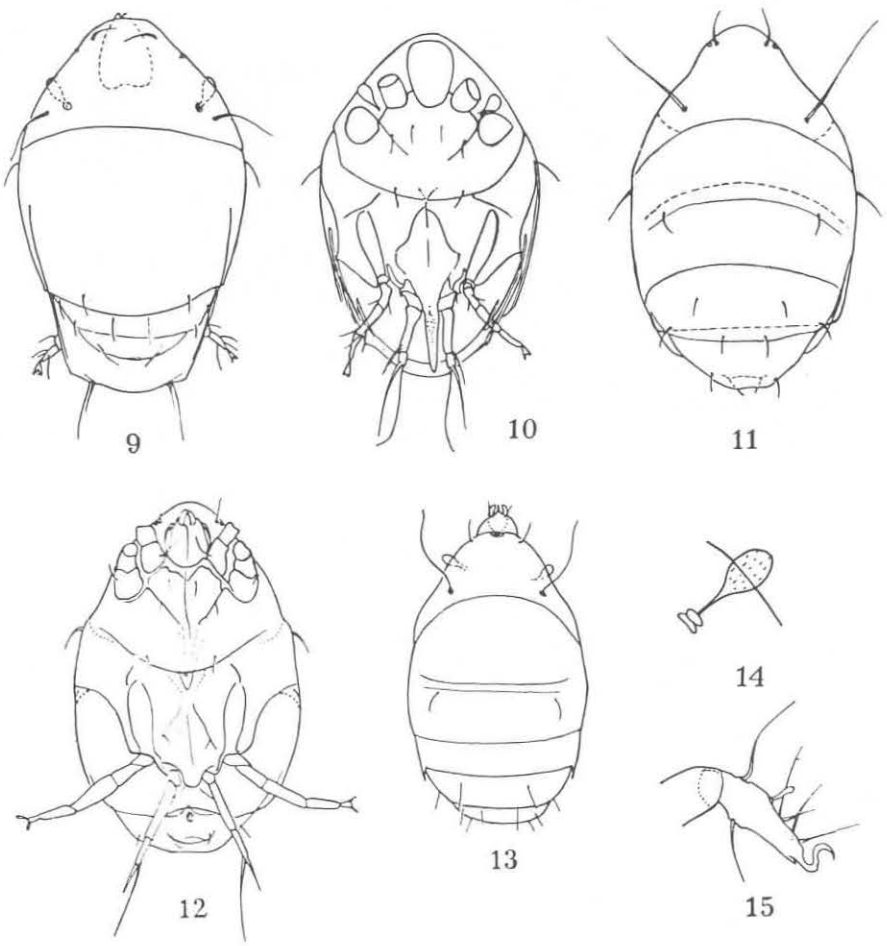

Fig. 9-15. *Tarsonemoides* spp. — Fig 9-10. *Tarsonemoides belemnitoides* n. sp. 9: dorsal. 10: ventral. — Fig. 11-12. *Tarsonemoides brevilobus* n. sp. 11: dorsal. 12: ventral. — Fig. 13-15. *Tarsonemoides monoporus* n. sp. 13: dorsal. 14: pseudostigmal organ. 15: Tarsus I.

parts are never seen from above. — The same sutures are met with as in *T. belemnitoides,* but in addition we find a median suture between coxae I.

The lobus is very short and with a rounded and blunt hind margin. It does not cover the anal aperture as is the case in the preceding species. — Trochanter III is large, and trochanter IV is very small.

It is distinguished from *T. uliginosus* and *T. belemnitoides* by having 1) more anteriorly placed pores (stigmata?), 2) weakly developed mantles, and 3) a short, broad, and blunt lobus (*brevilobus!*).

The species is recorded from the Plain and the Southern Meadow in small numbers.

Tarsonemoides monoporus n. sp.

Concerning this species some reservation in necessary. It is not a typical member of the genus *Tarsonemoides*, thus there is not a typical camerostome. But *T. monoporus* has a well developed suture between the metapodosoma and the opisthosoma, in contrast to the genus *Tarsonemus*. — It resembles *T. brevilobus* in many respects.

L. 0,140 mm. W. 0,075 mm. Fig. 13-15.

Dorsal (fig. 13). The pores are not situated at the lateral margins. Apparently they are fused to a single distinct pore at the anterior margin of the propodosoma (*monoporus!*). — The pseudostigmal organs are club-shaped (fig. 14), The shaft is thin, the head is pear-shaped and provided with numerous tiny hairs (immersion lens).

Ventral. The lobus is blunt and short like that of *T. brevilobus*. — The coxal plates are completely separated. The hair, in the two preceding species inserted in the suture between coxa I and II, is situated at the front margin of the coxal plate II.

References: Trägårdh, I. 1904. Acariden aus Ägypten und dem Sudan. Swedish Zool. Expedition to Egypt and the White Nile 1901.

Willmann, C. 1942. *Acari* aus nordwestdeutschen Mooren. Abh. Nat. Ver. Bremen. Vol. 32.

Endeostigmata.

Nanorchestes arboriger Berlese 1905.

Described 1905 by Berlese and later by Thor (1931 and 1941). However, the animals in my material differ in certain respects from the descriptions given by Berlese and Thor (fig. 16-21): 1) The general appearance is different (Berlese's figure, 1905), the animals being smaller and more slender (0,170×0,090 mm. Berlese: 0,200×0,120 mm. Thor: 0,200×0,140 mm). A distinct constriction between the metadoposoma and the opisthosoma is invariably present (fig. 16-17). 2) The anterior pair of pseudostigmal organs is only pectinated distally (fig. 16). 3) The arborescent hairs (fig. 21), scattered all over the hysterosoma, are smaller (0,003-0,005 mm. Berlese and Thor: 0,008 mm). 4) The anterior pair of legs (fig. 18) is distally thickened, a feature neither described nor figured by Berlese and Thor. — Chelicer: fig. 18. — Palpus: fig. 20.

I have not examined Berlese's and Thor's specimens. The relative differences mentioned above do not justify the erection of a new species at present. — The nymphs resemble the adults, but the arborescent hairs are relatively smaller.

Further information: see the figures.

References: BERLESE, A. 1905. Redia. Vol. 3.

THOR, S. 1941. *Eupodidae, Cheyletidae* etc. Das Tierreich. Lief 71.

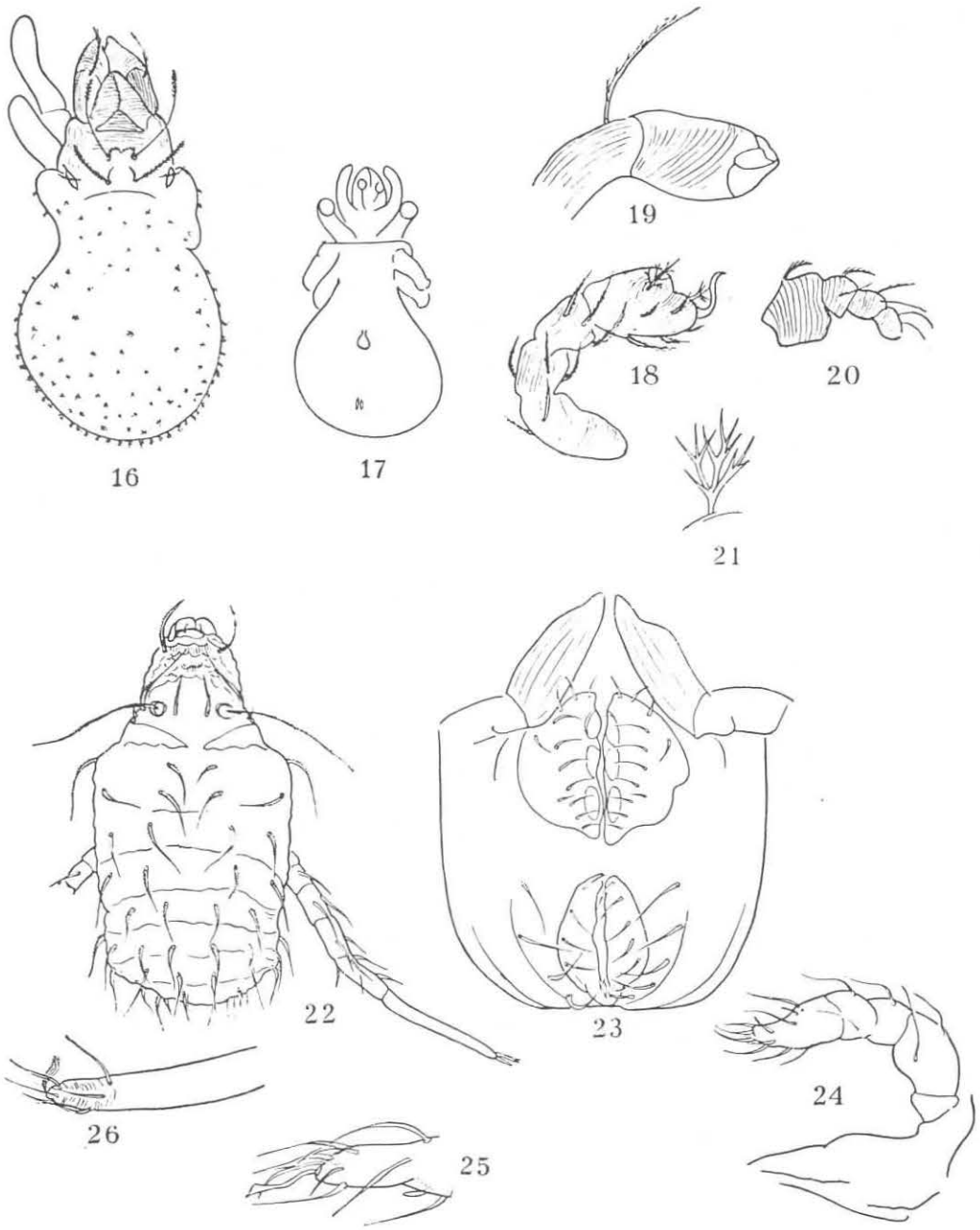

Fig. 16-26. *Nanorchestes* and *Terpnacarus*. Fig. 16-21. *Nanorchestes arboriger* BERLESE. 16: dorsal. 17: ventral. 18: leg I. 19: chelicer. 20: palpus. 21: hair from hysterosoma. — Fig. 22-26. *Terpnacarus subterraneus* n. sp. 22: dorsal. 23: ventral. 24: palpus. 25: palptarsus. 26: tarsus I.

Terpnacarus subterraneus n. sp.

The genus *Terpnacarus* was erected by GRANDJEAN 1939. He described in great detail the type species, *T. Bouvieri* GRANDJEAN. The principal features of the genus are as follows: Opisthosoma with 8 distinct segments, each provi-

ded with 2 pairs of strong hairs. 3 eyes, two are lateral eyes, the third is a frontal eye situated below the epivertex. 12 pairs of hairs on the genital valves (eugenital hairs). Coxa IV with a saltatory mechanism.

The thorough description of *T. Bouvieri* by GRANDJEAN makes it necessary to mention only the differences between the two species: 1) *T. subterraneus* (fig. 22-26) is smaller, L. 0,230 mm, W. 0,115 mm. 2) The two medial pairs of hairs on the mediodorsum (dorsal aspect of the metapodosoma) are situated the one in front of the other, and they do not form any transverse line (fig. 22). In this respect *T. subterraneus* resembles the genus *Alycosmesis* (see GRANDJEAN 1939). 3) The trichobothria and the pair of hairs situated just lateral to the conspicuous bases of the former are the most prominent hairs on the propodosoma, as is the case in *T. Bouvieri*, but the trichobothria are twice as long as the latter. They are delicately hairy. Except for the hairs situated just above the lateral eyes all the other hairs are pectinated (fig. 22). 4) The anal valves (fig. 23) carry 5, perhaps 6, pairs of hairs (*T. Bouvieri*: 4). 5) The tarsus of the palpi (fig. 25) is not provided with any dorsal protuberance. The lancet-hair is inserted terminally on the blunt tarsus. The solenidion is relatively smaller. 6) The chelicerae are relatively longer and carry 2 dorsal hairs, the proximal three times as long as the distal. — Tarsus I, fig. 26.

Locality: the dry part of the Plain.

References: GRANDJEAN, E.: Quelques genres d'Acariens appartenant du groupe des *Endeostigmata*. Ann. Sci. nat. Zool. (11). 2.

Speleorchestes termitophilus TRÄGÅRDH 1909.

Only two individuals were found. They resemble very closely the species described by TRÄGÅRDH in 1909 from Zululand.

References: TRÄGÅRDH, I. *Speleorchestes*, a new genus of saltatory *Trombidiidae*. Arkiv f. Zoologi. Vol. 6.

Tydeidae.

Tydeus tridactylus n. sp.

The species is a common representative of the *Tydeidae* on the Plain. I have found it in many other localities too. The species seems to be widely distributed as it was identified in material collected by HAARLØV in Greenland (HAARLØV's *Tydeus croceus* 1942).

Adults: L. 0,240 mm. W. 0,100-0,110 mm. Fig. 27-32.

General appearance: much like *Tydeus croceus* LINNÉ and *T. interruptus* THOR.

Dorsal (fig. 27). The furrow between propodosoma and hysterosoma (the body furrow) is interrupted, as in *T. interruptus* the median third is absent.

The propodosoma (L. 0,080 mm. W. 0,110 mm) is triangular. — The hystero-

soma (L. 0,150 mm. W. 0,100-0,110 mm), the lateral margins of which are slightly convergent, terminates transversely. — The maxillary organ is plainly seen from above. — The integument is distinctly striped (fig. 28. Nymph). Each stripe consists (immersion lens!) of a pair of integumentary lines provided with dots. On the propodosoma the stripes run longitudinally as they also do on the anterior part of the hysterosoma except for the area just behind

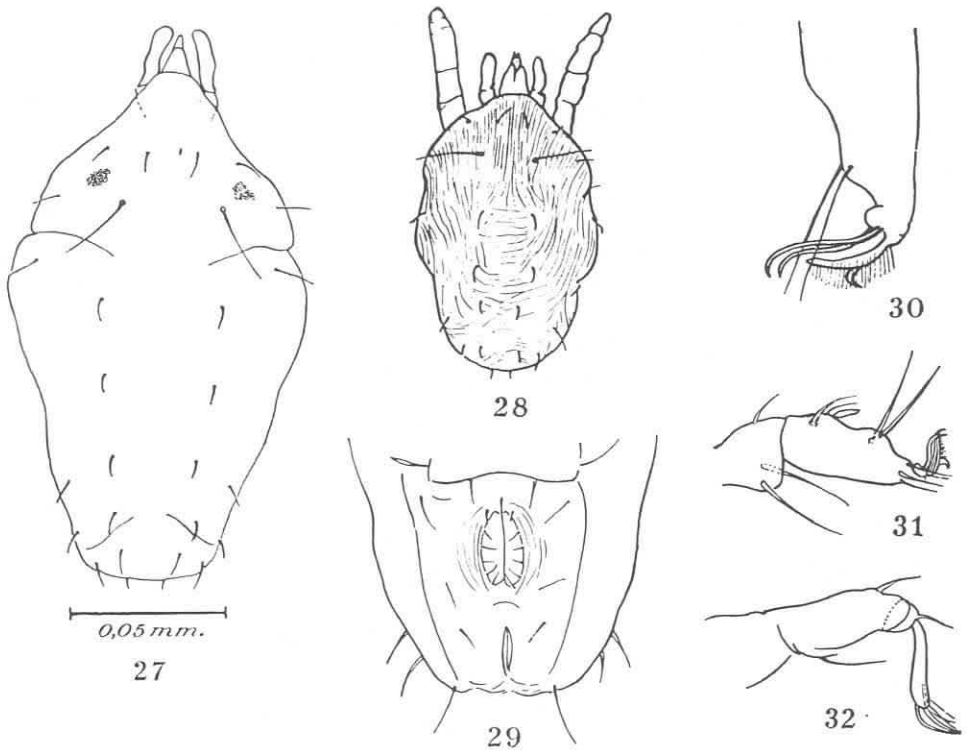

Fig. 27-32. *Tydeus tridactylus* n. sp. 27: adult, dorsal. 28: nymph, dorsal. 29: adult, ventral. 30: adult, tarsus I. 31: nymph, tarsus I. 32: palpus.

the setae humerales internae, this area being provided with transverse stripes. The same applies to the posterior part of the hysterosoma.

Chaetotaxis. The hairs are simple and pointed. The trichobothria are simple too. They are 0,035 mm long. The remaining hairs are short, 0,010-0,015 mm. Setae verticales externae et internae form a transverse line. The relatively pronounced eyes are situated just behind the external hairs. The setae scapulares externae and the trichobothria form a transverse line also. The two lines divide the propodosoma into three zones of approximately the same width. The setae on the hysterosoma, see fig. 27.

Ventral (fig. 29). The gnathosoma is short and broad, L. 0,040 mm. W. 0,030 mm. The chelicerae are fused. The palpi (fig. 32) resemble those of *T. croceus* LINNÈ. The pharynx is situated between the proximal segments of the palpi. The maxillary organ protrudes below the chelicerae. Distally it carries two, perhaps three, pairs of hairs, laterally the usual pair. — Genital region, see fig. 29.

Legs. The legs are short and thick. A cylindrical dorsal sense hair is inserted proximally on tarsus I (fig. 31. Nymph). — A very characteristic feature, unique among *Tydeidae* as far as I know, is the presence of a pulvillar claw (fig. 30-31): the empodium consists of the pulvillum, the ventral surface of which, however, carries a short but strong claw (*tridactylus!*). The ambulacral claws are long and slender and of usual shape. All legs of all developmental stages are provided with pulvillar claws.

The nymphs (fig. 28) resemble very closely *Tydeus curtus* BERLESE 1910. His very rough description and figure does not, however, permit identification.

Tydeus tridactylus resembles *Tydeus croceus* LINNÉ, but 1) *T. tridactylus* is smaller, 2) the body furrow is interrupted, and 3) it possesses a pulvillar claw.

T. tridactylus can be distinguished from *T. interruptus* by the following features: 1) the hairs of *T. tridactylus* are shorter, 2) the integument is distinctly striped, 3) the chelicerae are fused together, and 4) the tarsus possesses a pulvillar claw.

References: HAARLØV, N. 1942. Se pg. 257.

THOR, S. 1933. *Tydeidae. Ereynetidae.* Das Tierreich. Lief. 60.

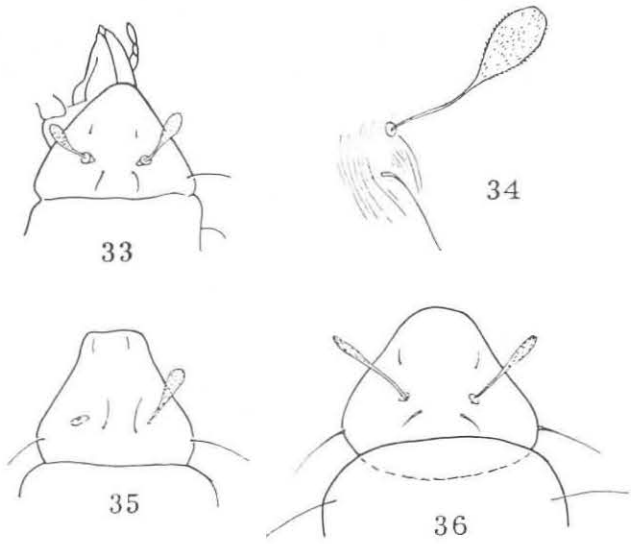

Fig. 33-36. *Coccotydeus frequens* GRANDJEAN. Pseudostigmal organs. 33: specimen from the Plain. 34: — do. —, higher magnification. 35: from Revlinghøj. 36: from Rogeshøj.

Coccotydeus frequens. GRANDJEAN.

All the individuals in my material apparently belong to this species, the only variation found refers to the trichobothria: *C. frequens* occurs only on the dry part of the Plain, whereas it is of common occurrence in the humid locality on Rogeshøj and in the intermediate locality on Revlinghøj. The specimens from the Plain have thick club-shaped trichobothria (see fig. 33—34), those from Rogeshøj slender and slightly thickened thrichobothria (fig. 36),

these organs having an intermediate shape in the animals from Revlinghøj (fig. 35). — This feature is perhaps analogous to the poorly developed pseudostigmal organs in oribatids characteristic of moist localities (e. g. *Platynothrus* and *Malaconothrus*).

Eupodidae.

Cocceupodes paradoxus n. sp.

This species resembles very much the other *Cocceupodes* species, especially *C. curviclava* THOR 1934, but the club-shaped setae verticales internae, present in the other species of the genus, are penniform in *C. paradoxus (paradoxus!)*-

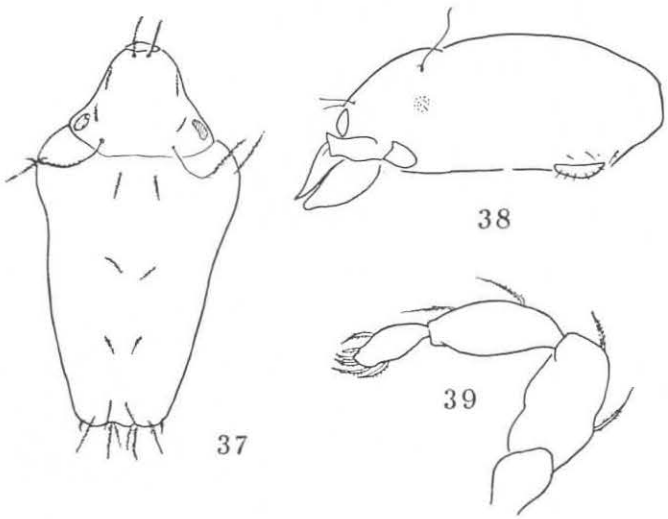

Fig. 37-39, *Cocceupodes paradoxus* n. sp. 37: dorsal. 38: lateral. 39: palpus.

L. incl. gnathosoma 0,250 mm, without gnathosoma 0.215 mm. W. 0,110 mm. Leg. I 0,230 mm. Leg IV 0,190 mm. Fig. 37-39.

The hairs are all penniform.

The integument lacks stripes, but bears many fine dots.

Dorsal (fig. 37). The »shoulders« are very conspicuous. — The suture between propodosoma and hysterosoma (body furrow) is present but weakly developed. — The propodosoma (L. 0,075 mm. W. 0,095 mm) appears to have been pushed into the hysterosoma, thus the body furrow runs forward at the lateral margins. The median part of the body furrow is a weak transverse line, the lateral parts, however are typically depressed. The large eyes are placed posteriorly at the lateral margins. The epivertex is of normal size and shape. The setae verticales internae are inserted just behind it (characteristic of the genus *Cocceupodes*) in distinct pores. As mentioned above these hairs are slender and penniform. The three remaining pairs of hairs (incl. trichobothria) form two longitudinal rows just medial to the eyes. The trichobo-

thria lie in deep pores close to the body furrow. They are 0,050 mm long, slender, and penniform also.

The hysterosoma, having a vase shaped outline (see fig. 37), has pronounced »shoulders« and a nearly straight hind margin. Apart from the shoulder hairs and those at the hind margin (0,025 mm) the remaining hairs are short (0,010—0,015 mm).

Lateral (fig. 38). The dorsal curvature is highly convex, as is the case in *Cocceupodes.*

Ventral. The genital valves are of normal shape and provided with six pairs of hairs, three in front and three behind the midline. Four pairs of hairs surround the valves. The epimeres I-II and III-IV almost touch medially. The uroporus lies terminally.

Gnathosoma. The chelicerae are of normal size. The mobile as well as the fixed digit is curved upward. The palpi (fig. 39) are of normal shape, the terminal segment carries 6—7 strong hairs. Segment II is 0,030 mm long, III 0,025 mm, IV 0,015 mm. The maxillicoxae are compressed laterally, in lateral view they are very conspicuous. A ventral and a lateral pair of hairs are present. — The legs are provided with two simple claws and a pulvillum. Tarsus I has two dorsal pairs of hairs, the one in the midline the other at the apex, in addition there are six pairs of ventral hairs. — Femur IV is thickened.

The species is recorded from the dry part of the Plain.

References: Thor, S. 1934. Neue Beiträge zur Kenntnis der invertebraten Fauna von Svalbard. Zool. Anz. Vol. 107.

Oribatei. Hypochthoniidae.

The genus *Brachychthonius.*

The original genus *Brachychthonius* has been subdivided into the genera *Eobrachychthonius*, *Brachychthonius*, and *Brachychochthonius* by Jacot, 1936. I use the term *Brachychthonius* in the original and broad sense, the species in my material belonging to the genera *Brachychthonius* and *Brachychochthonius* (Jacot).

Brachychthonius (Berlese 1910).

Brachychthonius sellnicki. Thor 1930
— *perpusillus.* Berlese 1910
— *brevis.* (Michael 1888),
— *furcillatus.* Willmann 1943.

Brachychochthonius berlesei. (Willmann 1928)
— *bimaculatus.* (Willmann 1936)
— *zelewaiensis.* (Sellnick 1928)
— *cricoides* n. sp.
— *furcatus* n. sp.

The following structures characteristic of the genus *Brachychochthonius* Jacot may be mentioned in order to facilitate the descriptions of the species *B. furcatus* n. sp. and *B. cricoides* n. sp.

a) The hystorosoma is flattened (*Brachychthonius* JACOT rounded), the dorsal and the ventral plates forming an acute angle laterally. b) The dorsal surface is distinctly sculptured (sculpturing rarely in *Brachychthonius* JACOT), the most constant elements are two longitudinal ridges on the medial part of the hysterosoma, running from the body furrow to the posterior margin. The medial pairs of hairs are inserted on these ridges. In some cases a pair of similar lateral ridges is met with (e. g. *B. cricoides*), but they are less distinct. A strong transverse ridge, always present on the posterior »segment« of the hysterosoma carries the fifth medial pair of hairs. Just behind this ridge the body wall turns down ventrally, the hind margin being slightly concave between the longitudinal ridges. c) the anal field terminates at the posterior margin of the body (*Brachychthonius* JACOT in front of the hind margin).

References: JACOT, A. P. 1936. Some primitive moss-mites of North Carolina. Journ. Elisha Mitch. Sci. Soc. Vol. 52.

JACOT, A. P. 1938. More primitive moss-mites of North Carolina. Ibidem. Vol. 54.

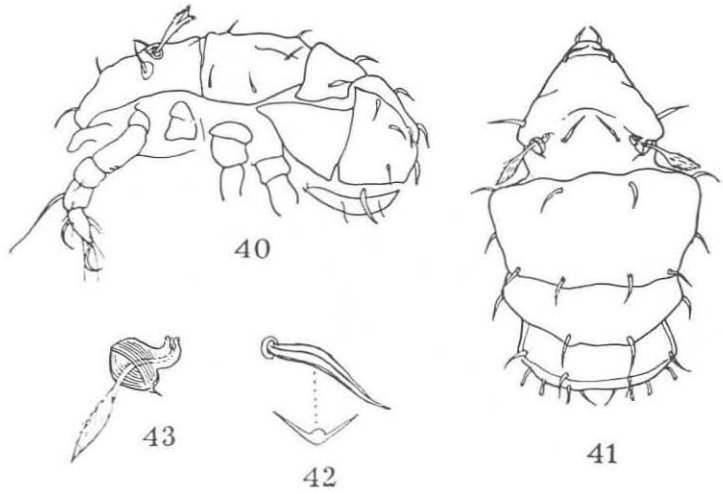

Fig. 40-43. *Brachychthonius sellnicki* THOR. 40: adult, lateral. 41: deutonymph, dorsal. 42: hair from the hysterosoma. 43: pseudostigma and pseudostigmal organ, dorsal view.

Brachychthonius sellnicki. THOR 1930. Fig. 40-43.

It is worthy of mention that the hairs of the hysterosoma (fig. 42) are formed like slender peachleaves (sometimes asymmetrical) which explains the peculiar appearance of the posterior hairs in THOR's figure and his misleading description. It may be noted, too, that the pseudostigmal organs (fig. 40) are forked as seen in lateral view, whereas they are spiciform seen from above (fig. 43). The same is true of *B. furcillatus* WILLMANN, *B. scalaris* FORSSLUND, *B. lapponicus* TRÄGÅRDH, all belonging to the genus *Brachychthonius* JACOT.

— The nymphs (fig. 41) resemble the adults, the posterior »segment« of the hysterosoma being shorter and narrower, however.

References: Thor, S. 1930. See pg. 255.

Brachychthonius perpusillus. Berlese 1910.

The animals correspond to Berlese's original description and figure. The animals referred to by Willmann 1931 under this name belong to another species.

References: Berlese, A. 1910. *Acari* nuovi. V. Redia. Vol. 6.

Willmann, C. 1931. *Oribatei*. Tierwelt Deutschl. Vol. 22.

Brachychthonius brevis. Michael 1888.

This is the species mentioned by Willmann 1928 and 1931 under the same name. The hairs are short and simple. The integument is supplied with numerous fine dots (immersion lens!). The pseudostigmal organ is spiciform and is provided with short adjacent spikes.

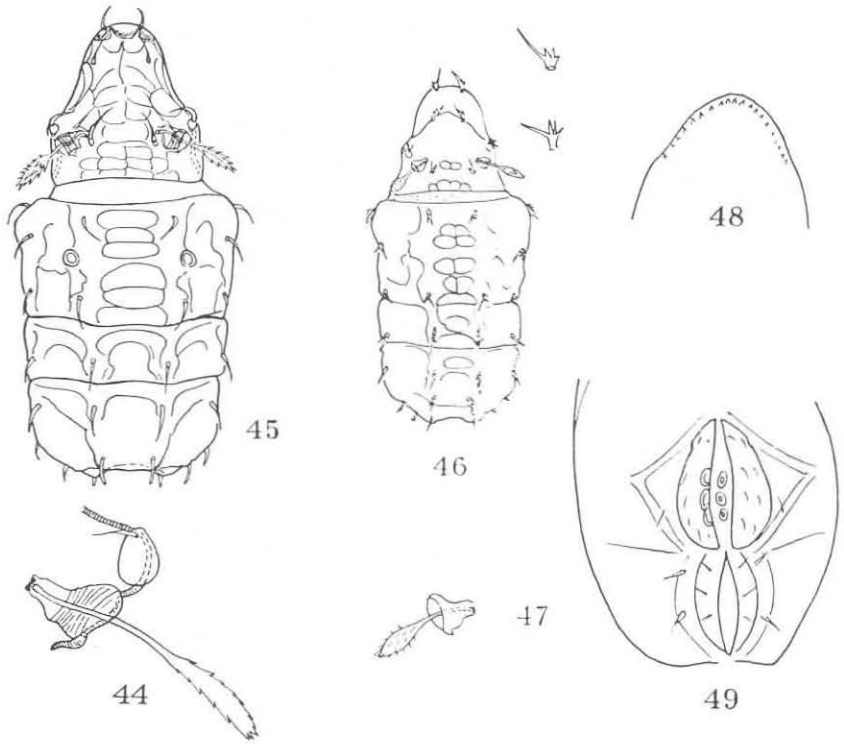

Fig. 44-49. *Brachychthonius* spp. Fig. 44. *Brachychthonius berlesei* Willmann. Pseudostigma and pseudostigmal organ. — Fig. 45. *Brachychthonius cricoides* n. sp. Adult, dorsal. — Ftg. 46-49. *Brachychthonius furcatus* n. sp. Adult. 46: dorsal. 47: pseudostigma and pseudostigmal organ. 48: rostrum, dorsal. 49: ventral.

References: Michael, A. D. 1888. British *Oribatidae*. Ray Soc. Vol. 2.

Willmann, C. 1928. Die Oribatidenfauna etc. Abh. Nat. Ver. Bremen. Vol. 27.

Willmann, C. 1931. See above.

Brachychthonius berlesei. WILLMANN 1928. (*Brachychochthonius b.*) Fig. 44.

This is the species of the same name described by WILLMANN 1928 and later by HAARLØV (1942). I only mention it on account of the pseudostigmata (fig. 44). The shape of the pseudostigmata in oribatids is often characteristic and has systematic value. In the genus *Brachychthonius* the pseudostigmata are funnel-shaped with a proximal tube and a distal cone. In *B. berlesei* the pseudostigma is asymmetrical, the tube forming a curve, the concavity of which faces backwards. On the posterior margin the cone possesses a small extension proximally and a chitinous process distally (the lateral and posterior part of the vertex line). — Further description, see HAARLØV 1942.

References: HAARLOV, N. 1942. See pg. 257.

WILLMANN, C. 1928. See above.

Brachychthonius cricoides n. sp. (*Brachychochthonius c.* n. sp.).

In certain respects *B. cricoides* resembles *B. berlesei,* a closer examination shows, however, many differences. It is perhaps the smallest known *Brachychthonius* species: L. 0,130-0,140 mm, W. 0,070-0,075 mm. Fig. 45.

Colour: almost colourless. — The hairs are of medium size and they are all simple. — The width of the propodosma is markedly less than that of the hysterosoma. The propodosoma has distinct lateral ridges and a semicircular vertex ridge between the pseudostigmata. — The pseudostigmata very closely resemble those of *B. berlesei,* the pseudostigmal organs, on the contrary, are thicker. They are spiciform and covered with short spikes. — The interlamellar hair is inserted just behind the pseudostigma. — The sculpture is conspicuous and gives the propodosoma a faceted appearance (fig. 45). Thus 3 pairs of medial and 2 pairs af lateral light reflecting plates are situated between the vertex ridge and the hysterosoma.

The shape and sculpture af the hysterosoma, see figure. The pair of pores situated laterally on the medial longitudinal ridges between the first and the second pair of hairs is especially characteristic. The pores are surrounded by a ring (*crieoides!*). Similar pores are present in *B. bimaculatus.* Some species possess simple pores without rings.

Brachychthonius cricoides resembles *Brachychochthonius jugatus* JACOT var. *suecica* FORSSLUND 1942 very much, but it deviates in the following respects: 1) the pores on the hysterosoma are surrounded by distinct rings. 2) it has two (not only one) pairs of lateral light reflecting plates behind the pseudostigmata. 3) the pseudostigmal organs seem to be thicker and the spikes seem to be stronger. 4) *B. cricoides* is smaller, 0,130-140 mm. (*B. jugatus* 0,160-170 mm)

Brachychthonius cricoides is common in raw humus from Rogeshøj and Revlinghøj.

References: Forsslund, K. H. 1942. Schwedische *Oribatei* I (*Brachychthonius* and *Oppia spp.*). Arkiv för Zoologi. Vol. 34 A.
Jacot, A. P. 1936. See pg. 267.

Brachychthonius furcatus n. sp. *(Brachychochthonius f.* n. sp.*)*

L. 0,140 mm. W. 0,070 mm. Fig. 46-49.

This species resembles *Brachychthonius bimaculatus* Willmann 1936 very much, but it lacks the big pores on the hysterosoma. No thorough description will be given here, but the following characteristics may be pointed out: 1) the pseudostigmal organs (fig. 47) in *B. furcatus* and *B. bimaculatus* are alike. 2) the same applies to the rostrum (fig. 48), the front margin of which is provided with short and broad spikes. 3) The hairs, on the other hand, are unique. They are all split, the branches being pointed (fig. 46). Usually there is a main branch and one or more minor branches. When using low magnifications (200-400 x) the front hairs on the hysterosoma look like forks (*furcatus!*). The exopseudostigmal hairs look like asterisks, whereas the posterior hairs on the hysterosoma are very coarsely pinnated. 4) The sculpture of the dorsal surface resembles that of *B. berlesei* (fig. 46). 5) the anterior margin of the genital valves is pointed (fig, 49), and the lateral margin is slightly concave. In *B. bimaculatus* the genital valves are blunt and they do not possess any concavity.

Brachychthonius furcatus is only recorded from the subterranean layers of the dry part of the Plain.

References: Willmann, C. 1936. Neue *Acari* aus schlesischen Wiesenböden. Zool. Anz. Vol. 113.

Type specimens and the original drawings:
Naturhistorisk Museum, Aarhus, Denmark.